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Soil parent material stratigraphy and soil development, Cedar County, Iowa

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by

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INTRODUCTION

The Tama soils which occur in Cedar, Muscatine, and Scott counties, Iowa, have atypical morphological features in the B horizon (Smith, Allaway, and Riecken, 1950; Arnold and Riecken, 1964). These soils have moderate to heavy coatings of light gray silt-sized grains, neo-skeletans, on the ped faces in the B horizon. This is not typical of modal Tama soils.

In east-central Iowa the distribution of these atypical Tama soils is generally found occurring in those areas other than that of the loess-mantled Iowa erosion surface (Arnold and Riecken, 1964; Fenton, 1966). Instead, the distribution of these soils is on paha or thick-loess-mantled surfaces where the loess generally reaches depths of 100 inches or more in thickness.

A large acreage of well and moderately well drained prairie-derived soils having grainy gray ped coatings in the B horizon occur along the Cedar-Wapsipinicon River divide in Cedar and Scott counties. The landscape geometry along this primary divide is atypical of the characteristic topography of the loess-mantled Kansan drift plain. The stable summit consists of broad level flats accented by swell-swale micro-topography. The maximum slope gradient is 2%. Normal to the primary divide secondary and tertiary interfluves and hill-slopes are characterized by long, gently sloping gradients dissected by a minimum number of first and second order drainageways.

These landscape and soil features pose the question as to whether there is a relationship between the parent materials, the nature of the parent material stratigraphy, and the characteristics of the associated ground soils.

Specifically the objectives of this study were:

1. Define and delineate the areal distribution of the parent materials and the nature of these parent materials for the geographic area parallel and normal to the Cedar-Wapsipinicon River divide in Cedar and Scott counties.

2. Evaluate the parent material units in terms of weathering zones and stratigraphic units.

3. Assess the roles of geogenic and pedogenic influence on the genesis of the ground soils.

4. Define the soil profile characteristics for well and moderately well drained prairie-derived soils formed on stable landscape positions in the study area and compare these soil characteristics to representative Tama soils from east-central Iowa.

5. Evaluate the degree of soil-landscape continuity or discontinuity for a hydrosequence of prairie-derived soils across a defined soil-landscape-parent material system.

The approach to this investigation involved the examination of coreholes along a reconnaissance traverse and along two transects. The reconnaissance traverse was parallel and normal to the Cedar-Wapsipinicon River divide. The two transects were selected on the basis of their geologic and pedologic characteristics. These observations were analyzed in terms of selected physical and chemical properties in the laboratory as well as in a three-dimensional field setting. The results of these observations were used to reconstruct the field systems and for the development of soil-landscape-parent material models.

SETTING

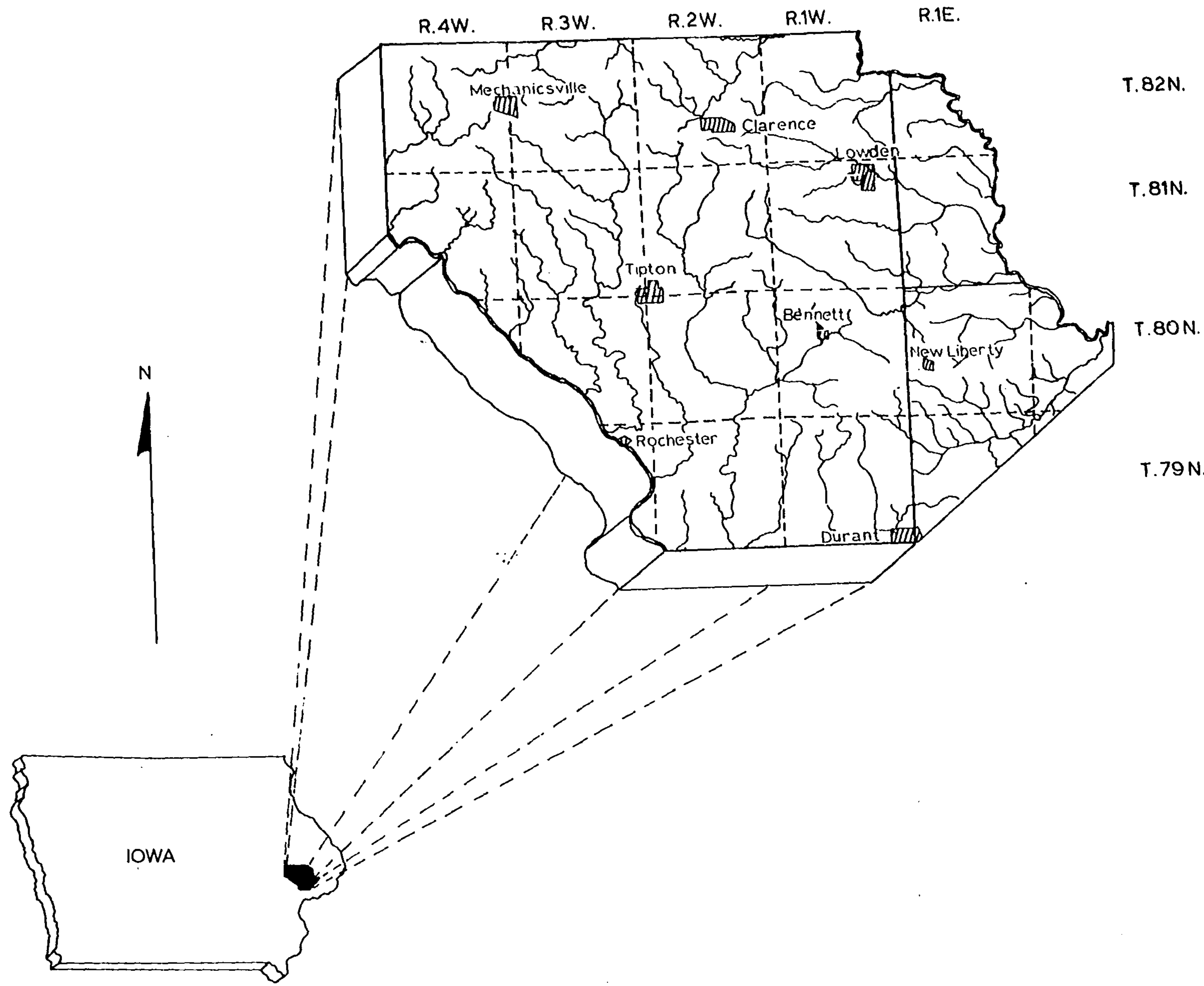
The study area is located in eastern Iowa and includes portions of townships T.79N. through T.82N. and ranges R.1E. and R.1W. through R.4W. (Figure 1). A reconnaissance traverse was constructed parallel to the topographic divide of the Cedar and Wapsipinicon Rivers (Figure 2). This traverse consisted of coreholes ranging in depths of 10 to 30 feet.

The landscape in the northern portion and an area located in the west-central part of the study area (Figure 2) has been classified as the Iowan erosion surface (Ruhe, Dietz, Fenton, and Hall, 1968). This land surface is characterized by subdued slopes and low relief marked by the occurrence of areas of isolated topographic highs, paha and inliers. The landscape is mantled with seven feet or less of loess on the Iowan erosion surface on Kansan till and older deposits.

The landscape in the remaining portion of the study area (Figure 2) has been designated as Wisconsinan loess on Yarmouth-Sangamon paleosol (YSP) on Kansan till (Ruhe, 1969a). This land surface is characterized by subdued slopes and low relief with a micro-topography of many closed depressions along the Cedar-Wapsipinicon interstream divide. Other parts of this area are marked by distinct staircases of ridges and tabular hillslope summits which are characteristic of the land surface in southern Iowa (Ruhe, 1969a, p. 88).

On the stable parts of the hillslopes the landscape

Figure 1. Location of the study area in eastern Iowa


R.4W.
R.3W.
R.2W.
R.1W.
R.1E.
T.82N.
T.81N.
T.80N.
T.79N.
Mechanicsville
Clarence
Lowden
Tipton
Bennett
New Liberty
Rochester
Durant
N
IOWA

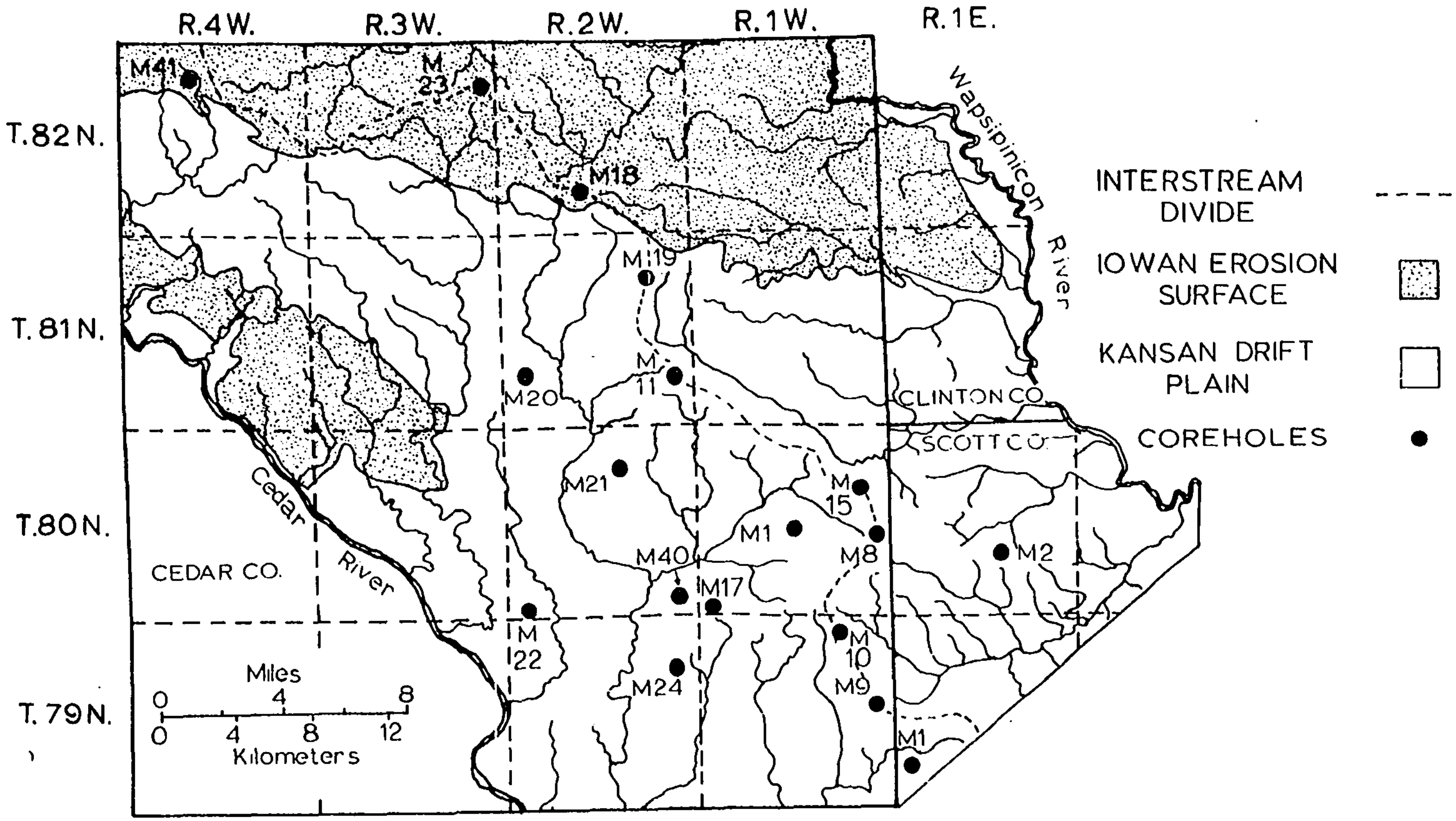


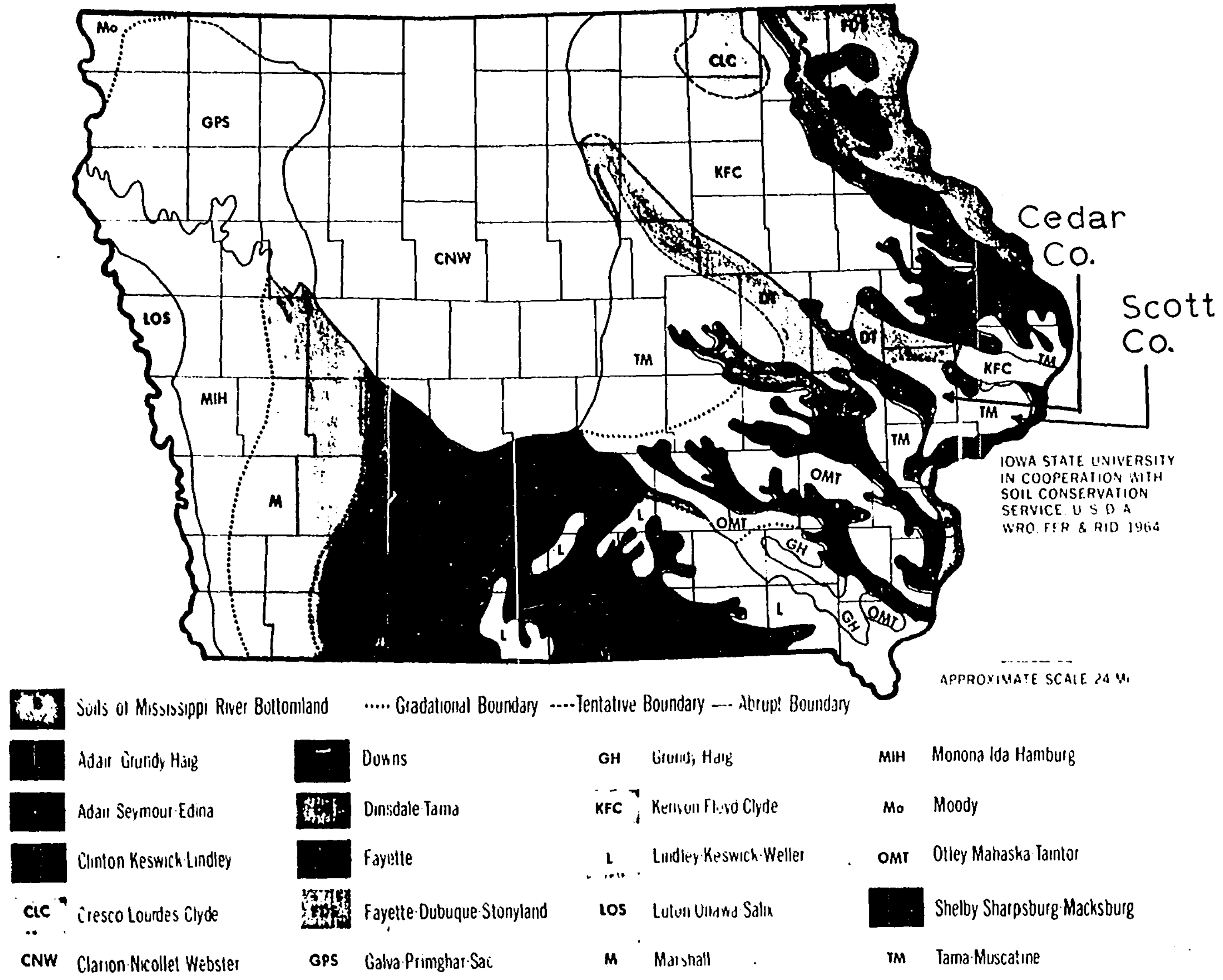
Figure 2. Location of the topographic divide between the Cedar and Wapsipinicon Rivers, and location of selected coreholes, Cedar and Scott counties

within the study area is mantled by 8 to 30 feet of loess.

The Dinsdale-Tama soil association area extends across the northern portion of the study area (Figure 3). The southern boundary of this soil association coincides with the limits of the Iowan erosion surface (Oschwald et al., 1965). The Tama-Muscatine soil association area extends parallel and adjacent to the primary divide of the Cedar and Wapsipinicon Rivers in the remainder of the study area (Figure 3. The Fayette soil association area is located in the southwest and east-central portion of the study area (Figure 3).

Figure 3. Soil association map of the State of Iowa showing areal distribution of the Tama-Muscatine and Dinsdale-Tama soil associations in Cedar and Scott counties

PRINCIPAL SOIL ASSOCIATION AREAS OF IOWA



BACKGROUND

The background section presents a discussion of the geology, weathering zones, and soils as related to the study area. The nature of the ground soils are influenced, along with other factors, by the material on which they are formed. An adequate knowledge of the sequence and characteristics of the geologic materials assist in developing an understanding of the properties of the ground soils.

Bedrock

The most complete summary of the bedrock and bedrock topography within the study area is in the Iowa Geological Survey reports for Cedar and Scott counties (Norton, 1899, 1901). Few rock outcrops occur within the study area as the maximum difference in surface elevation is approximately 250 feet across the entire study area. Most of the study area is underlain by Silurian dolomites with some Devonian dolomites and limestones in the southwestern part of the area (Norton, 1899, 1901; Iowa Geological Survey, 1969).

The nature of the bedrock surfaces and the origin of the buried bedrock valleys on these surfaces have been subject to investigation by many researchers. Leverett (1895) discussed evidence of a preglacial channel which extended from the mouth of the Wapsipinicon River, southwest across Scott, Cedar, and Muscatine counties. He noted that the channel had cut a deep valley into the bedrock. Subsequently, the channel had been filled with 200 to 300 feet of unconsolidated sediments.

Udden (1899) mapped a portion of the channel in Muscatine County. He used local well records and compiled a bedrock topography map for the bedrock channel. His map indicated that the channel was filled with more than 225 feet of unconsolidated materials.

In the geology report for Scott County, Norton (1899) also used well records to trace the channel from the southwest corner of the county to the confluence of the channel with the Wapsipinicon River. He designated this preglacial valley the Cleona channel.

Two years later in the geology report for Cedar County Norton (1901) mapped another preglacial valley. This bedrock valley cuts across the entire county along a northwest-southeast axis. Norton (1901, p. 297) termed this preglacial valley the Stanwood channel. Norton noted that the Stanwood channel was buried below more than 300 feet of unconsolidated sediments. In addition, he noted that there is no evidence on the present land surface to reveal the existence of the Stanwood channel. Norton (1901, p. 299) mapped the buried Stanwood channel with sufficient detail to show that it joined the preglacial Cleona channel near the town of Durant, Cedar County. In several wells more than 100 feet of basal sands were identified above the surface of the buried Stanwood channel.

Later investigators have questioned whether the bedrock valleys were on the bedrock surface prior to Pleistocene glaciation or whether these valleys were a product of glacial erosion.

In the reconstruction of preglacial topography in Illinois Frye (1963) suggested that the deep bedrock valleys were carved during glacial time. Anderson (1968) suggests that the bedrock topography of the study area may have evolved during either Nebraskan or Kansan time.

In northwestern Missouri Heim and Howe (1963) proposed that the bedrock valleys were developed during both preglacial and Nebraskan time.

Recently, Hansen (1972) has published a bedrock topography map for east-central Iowa. This map includes all of the study area.

Pleistocene Geology

Drift deposits

McGee (1891) compiled the first detailed geology report on deposits which occur within the study area. All of the land area included in the present study is within an area designated by McGee (1891, p. 359) as being a ridged drift topography of northeastern Iowa.

Norton (1899, 1901) authored the Iowa Geological Survey reports for both Scott and Cedar counties. Within the study area discussed in this dissertation Norton recognized the following Pleistocene units from youngest to oldest:

Loess
Iowan drift
Buchanan gravels
Kansan ferretto
Kansan till
Aftonian peats
Pre-Kansan till

The Pre-Kansan till was identified in some well-logs. However, he noted that this older till deposit was recognizable only by contacting the darker colored Aftonian peats. He noted that this older till was not exhumed by erosion. Norton (1899, 1901) concluded that Kansan drift extended over the entire land area of Cedar County and over the northwestern part of Scott County.

In the west-central part of Cedar County Bain (1898) mapped a lobe-like deposit of drift which he correlated with the Iowan drift. This deposit was identified as extending along a line adjacent to the north bank of the Cedar River and was designated the Tipton lobe (Norton, 1901, p. 367). In addition, Bain (1898) identified a drift sheet which extended across the northern townships of Cedar County and into Clinton County to the east. This drift sheet was also correlated as Iowa drift (Bain, 1898). Later Norton (1901, p. 367) designated this latter drift sheet as the Clinton lobe. Norton's (1901) conclusion that these lobes represented Iowan drift was based on the topography of the drift sheets and the relationship of these areas to other areas of the Iowan drift previously described by Calvin (1899).

Even though Norton (1901) identified the presence of Iowan drift in Cedar and Clinton counties, in the same report he questioned the thickness and extent of erosion and aggradation of the Iowan glacier.

Subsequent work concerning the Iowan drift in this area was reported in 1917 (Alden and Leighton, 1917). Alden and Leighton (1917) visited Cedar County during their field study concerning the existence and areal distribution of the Iowan drift. They (p. 178) acknowledged that little data were available to confirm the presence of Iowan drift in northern Cedar County or southwestern Clinton County. Furthermore, they concluded that it was doubtful if Iowan ice ever occupied the area designated by Norton (1901) as the Tipton lobe. Yet Alden and Leighton (1917, plate XIV) failed to alter the boundaries of the Iowan which had been established for Cedar and Clinton counties in previous reports (Bain, 1898; Calvin, 1899; Norton, 1901).

Field geologists' interpretation and identification of the Iowan drift and the boundaries of the drift plains in Cedar and Clinton counties remained unchanged (Kay and Graham, 1943, p. 103; Scholtes, 1955) until recent renewed interest in the Iowan.

During the 1960's Ruhe and associates showed that the Iowan drift was nonexistent. Instead, the area consisted of a complex erosion surface cut into Kansan and older tills (Hall, 1965;

Fenton, 1966; Dietz, 1967; Ruhe et al., 1968). The area was redesignated the Iowan erosion surface complex (Ruhe et al., 1968).

The landscape adjacent to the Iowan erosion surface has simply been referred to as the Kansan drift plain (Kay and Apfel, 1929; Kay and Graham, 1943; Ruhe, 1956). Recently, Ruhe (1969a) designated this area as Wisconsin loess on Yarmouth-Sangamon paleosol on Kansan till. At the commencement of this study the general Quaternary stratigraphy for all of Cedar County, southwestern Clinton County, and northwestern Scott County was recognized as shown in Table 1.

Upland sand deposits

Norton (1901) noted that stratified sands occurred in the loess along the boundaries of the Iowan. In fact, Calvin (1899) and Norton (1901) used these sand deposits as a characteristic to distinguish Iowan from adjacent material. Norton (1901, p. 370) stated that he rarely observed sands in the Kansan drift area except at the abutting Iowan boundary.

Arnold (1963, p. 127) identified sands in the basal increment of loess in sec. 26, T.80N., R.1W., Cedar County. These sands were collected from coreholes and he did not have sufficient observations to quantify the thickness or areal distribution of these sands.

In the study of the Iowan erosion surface (Ruhe et al., 1968) a sand zone was identified at the loess-truncated till

Table 1. General Quaternary section for the study area in eastern Iowa

Time-stratigraphic[a]	Evidence	Authority
	East-central and eastern Cedar Co.; northwestern Scott Co.	
Holocene	Erosion, construction, weathered zones	Ruhe (1969a, p. 129-168)
Wisconsinan	Loess, weathered zones	Kay and Graham (1943, p. 159-160)
Basal Wisconsinan	Soils, organic zones, weathered zones	Ruhe (1968b, p. 56-61)
Late Sangamonian	Soils, weathered zones, erosion surfaces	Ruhe and Scholtes (1956, p. 266-267)
Yarmouthian-Sangamonian	Soils, weathered zones, erosion	Ruhe and Scholtes (1956, p.266-267)
Kansan	Drift	Kay and Apfel (1929, p. 228-231)
Aftonian	Soils, peat, weathered zones, erosion	Kay and Apfel (1929, p. 199-204)
Nebraskan	Drift	Kay and Apfel (1929, p. 146-154)
	West-central and northern Cedar Co.; southwestern Clinton Co.	
Holocene	Erosion, construction, weathered zones	Ruhe (1969a, p. 129-168)

[a]Formal names updated by author.

Table 1. (Continued)

Time-stratigraphic	Evidence	Authority
Wisconsinan		
Late	Loess, weathered zones	Ruhe et al. (1968)
Iowan Erosion Surface (uncomformity)	Erosion, weathered zones	
Early	Loess, weathered zones	
Basal Wisconsinan	Soils, weathered zones, erosion surfaces	Ruhe and Scholtes (1956, p. 266-267)
Late Sangamonian	Soils, weathered zones, erosion surfaces	Ruhe and Scholtes (1956, p. 266-267)
Yarmouthian-Sangamonian	Soils, weathered zones, erosion	Ruhe and Scholtes (1956, p. 266-267)
Kansan	Drift	Kay and Apfel (1929, p. 228-231)
Aftonian	Soils, peat, weathered zones,	Kay and Apfel (1929, p. 199-204)
Nebraskan	Drift	Kay and Apfel (1929, p. 146-154)

interface. These sand zones generally blanket the truncated till surface and are intercalated with the loess on the paha. They (Ruhe et al., 1968) concluded that the source of the sand was from the loam till into which the erosion surface was cut.

Loess deposits

Norton (1901) mapped loess deposits with thickness up to 40 feet in the area south of the Iowan boundary in Cedar County. He concluded that the loess thickness probably did not exceed 10 to 15 feet in the loess-mantled Kansan drift area.

The broad, flat loess-mantled plains of the Cedar-Wapsipinicon River divide were identified by Norton (1899, 1901) as a plain on the Kansan drift surface.

Kay and Apfel (1929, p. 57) and Kay and Graham (1943, p. 163) include the loess-mantled Kansan drift plain in the general category of loess-mantled erosional topography. They concluded that loess could influence erosional topography by: (1) increasing the relief by deposition of more loess on the divide areas than in the valleys, (2) reducing the relief by deposition of more loess in the valleys than on the divides, and (3) causing no distinct alteration of the slope angles. In view of the prevailing topographic features of the general area in Cedar and Scott Counties Kay and Apfel (1929) concluded that the divides were covered with not more than 10 feet of loess. In the valleys the loess thickness may reach 30 to 40 feet.

Simonson, Rieeken, and Smith (1952, p. 15) published a loess thickness map for the State of Iowa. The loess thickness was identified as being 16 or more feet on the broader ridges for the Kansan drift area which is included in this study. The loess thickness was given as 3.5 feet or less for the land surfaces within the boundaries of the Iowan.

Ruhe (1969a, p. 33) presents a loess thickness map of the State of Iowa. His map deviates little from the loess thickness map of Simonson et al. (1952), for areas included in this study. However, Ruhe (1969a) shows loess thickness up to 32 feet abutting the Iowan border.

Weathering Zones

Weathering zones in unconsolidated sediments have been described on the basis of the presence or absence of carbonates and oxidation states. The terminology of weathered zones in Quaternary deposits in Iowa has a long history (Kay, 1916b; Kay and Pearce, 1920; Kay and Apfel, 1929, p. 162). In other areas of the Upper Mississippi Valley numbers have been applied to designate weathering zones (Leighton and MacClintock, 1930). More recently, mineral zonations have been successfully used to differentiate weathering zonation (Frye, Glass, and Willman, 1962, 1968; Kleiss and Fehrenbacher, 1973). The background presented in this dissertation will pertain to carbonate solution and oxidation states.

Carbonate solution

Solution refers to the process by which water molecules are added to the sediment matrix causing dissolution of carbonates, simple salts, and chlorides. The dissolution of carbonate minerals occurs in the presence of carbon dioxide. Increases in the carbon dioxide pressure on hydrogen ion concentration will increase the rate of carbonate dissolution (Krauskopf, 1967, p. 108).

The presence or absence of the more soluble bases, calcium and magnesium carbonates, in unconsolidated sediments have been described in terms of leaching.
The leaching process commences with the removal of carbonates. The process involves the formation of carbonic acid:

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

which in turn reacts with the carbonates or calcite:

$$CaCO_3 + H_2CO_3 \longrightarrow Ca^{++} + 2HCO_3^-$$

which results in the production of a highly mobile calcium ion and the formation of bicarbonate. The rate of leaching is a complex process and dependent on a series of physical and chemical parameters (Ruhe, 1969b, p. 8). Richardson (1974) showed that the initial removal of carbonates provides the reference point for soil acidity studies.

Unleached weathering zones in unconsolidated sediments are calcareous. Smith (1942), Hutton (1947), Frye and Leonard (1952, p. 129), Worcester (1973, p. 87) and others have assumed that loess particles were originally deposited in a calcareous matrix. Similar assumptions have been made for till deposits in Iowa (Kay, 1916b; Kay and Pearce, 1920; Kay and Apfel, 1929; Kay and Graham, 1943). Therefore, the terms leached and unleached provide utility for descriptive purposes.

Oxidation states

Oxidation refers to the state of aeration. Oxidized sediments exist in an environment where the oxygen supply is high or the oxygen supply exceeds the biological oxygen demand. In the oxidation process of unconsolidated sediments iron is the most commonly oxidized element (Carroll, 1970, p. 113). The oxidation of iron from the ferrous to the ferric state, in the weathering process of common rock-forming minerals, disrupts the electrostatic neutrality of the crystal lattice. This disruption allows for the collapse of the crystal lattice or promotes an additional weathering process. The release of the iron by the weathering process, in the presence of oxygenated water, allows for formation of an oxide, Fe_2O_3 (hematite), or hydrous oxides such as $Fe_2O_3 \cdot H_2O$ (goethite), and $2Fe_2O_3 \cdot 3H_2O$ (limonite). The oxidation of manganese is more complex due to the number of oxidation states it possesses. However, manganese is weathered to an oxidized form in an aerated environment. The products of manganese oxidation are dark brown or black.

Reduction or deoxidation occurs in an environment where the oxygen supply is limited or the biological oxygen demand is high. This process occurs where the sediments are in an environment of saturation or near-saturation. The occurrence of these moisture regimes are related to either permanent or temporary high water tables and the presence of organic materials and microorganisms. In a deoxidized environment the iron is reduced to a highly mobile ferrous form (Cate, 1964). The ferrous iron may be lost to the sediments if there is a net movement of the groundwater. If, on the other hand, the ferrous iron remains in the sediment matrix it may move into crevices or channels within the sediment and be oxidized or remain in the matrix and react with sulfides in the reduced state.

An unoxidized state occurs when the sediment matrix has not been exposed to oxygen or oxygenated waters. In the unweathered common rock-forming minerals the iron exists in the ferrous state.

The state of oxidation has generally been associated with matrix colors and the chemical status and distribution of iron. The oxides of iron apparently have optical properties which may be determined by the distance between iron atoms. These properties are due to the allochromatic nature of the iron compound. For example, Fe_2O_3, hematite, has an iron-iron distance of 2.88 Å and has a red color (Pauling, 1960, p. 438). The hydrated iron oxides, such as goethite and limonite tend to be lighter in color. A reduced form of iron, iron sulfide, has an iron-sulfide distance of 2.27 Å and has a very light color (Pauling, 1960, p. 248). The bluish and dark gray colors of ferrous oxide are apparently the result of iron existing in two valence states in the reduced form (Mason and Berry, 1968,

p. 111). Then color is not a true guide for oxidation states because color is dependent on chemical subdivisions and on minor impurities as well as the degree of hydration (Krauskopf, 1967, p. 108).

Historical development

The use of oxidation states to describe characteristics of soils and their parent materials was introduced by Russell (1889, p. 15) in his study of soils from a variety of rock formations in the southeastern United States. He identified accumulations of ferric oxide coatings on primary minerals in the weathered products of granites, diorites, and limestones, as well as other dark-colored rocks.

The terms oxidation and deoxidation were introduced by Van Hise (1904, p. 204, 461-473) in his classical treatise regarding the belt of weathering. Van Hise (1904) discussed oxidation states in terms of the chemical status of iron. He concluded that the presence of deoxidation zones in unconsolidated sediments was the result of an inadequate supply of oxygen (p. 608). He suggested that the oxygen in the system was insufficient to dominant all chemical reactions which occurred. Therefore, deoxidation occurred in environments of limited oxygen where some of the oxygen may be utilized for other chemical and biological reactions. He considered a case where soils and soil materials existed in semi-saturated conditions. In this situation he hypothesized that large quantities of oxygen would be required to decompose plant residues. The biological oxygen demand would exceed the oxygen supply, resulting in oxygen becoming the limiting factor. This would result in the extraction of oxygen from the ferric oxide. This process would then allow for the deoxidation of iron compounds at the expense of the oxidation of the organic constituents.

In field studies conducted in the Upper Mississippi Valley and especially in Iowa, the color ranges for the oxidized zone include reddish-brown, yellowish-brown, and olive brown (Kay and Pearce, 1920; Kay and Apfel, 1929; Kay and Graham, 1943; Ruhe, 1954; Ruhe, Prill, and Riecken, 1955; Ruhe, 1969a). Fenton (1966) defined the matrix of the oxidized zone as having hues of 2.5Y or redder with values of 3 or higher and chroma of 2 or higher. Gray mottlings could make up 10 to 40% of the matrix.

The color range for the matrix of the deoxidized zone has been centered on a gray or light gray hue (Kay, 1916b; Ruhe, 1954; Ruhe et al., 1955; Ruhe and Scholtes, 1956; Daniels, Simonson, and Handy, 1961; Fenton, 1966; Ruhe, 1969a). Fenton (1966) defined the colors of the deoxidized matrix. His criteria required that at least 60% of the sediment matrix contain hues of 2.5Y and 5Y having values of 5 and 6 with chroma of 1 and 2. Segregated iron could exist in the deoxidized zone in the form of concretions and tubules. The color of these segregations would be similar to the colors observed in the matrix of the oxidized zone (Fenton, 1966).

The colors observed for an unoxidized matrix include dark gray, dark greenish gray, greenish gray, green, blue, and bluish gray (Kay, 1916a; Kay and Pearce, 1920; Kay and Apfel, 1929; Kay and Graham, 1943; Ruhe, 1954; Ruhe and Scholtes, 1956; Daniels et al., 1961; Fenton, 1966; Ruhe, 1969a). Fenton (1966) defined the colors of the unoxidized matrix to include hues of 5Y, 5GY, 5BG, and 5G having values of 4 and 5 with chroma of 0 and 1. Segregation of iron into nodules or tubules does not occur in the unoxidized zone.

The actual chemical status of iron in the oxidation zones has been studied only within recent times.

Oxidized zones have a free iron oxide content, defined chemically by the extraction with sodium hydrosulfite and expressed as an oxide, which vary from 1.5 to 3.5% (Ruhe, 1969a, p. 49). Extraction of free iron oxide by the sodium dithionite-sodium citrate method (Holmgren, 1967) from oxidized zones in loess has yielded values from 0.8 to 1.7% (Fenton, 1966; Huddleston, 1969; McKim, 1972).

In the oxidized zone the ferrous iron content expressed as an oxide varies from 1×10^{-4} to 5×10^{-4}% (Daniels et al., 1961).

Data for free iron oxide and ferrous iron in deoxidized matrices are also available (Daniels et al., 1961). These results were obtained from samples in deoxidized zones of both loess and till from western and central Iowa. Their results indicated that the reduced iron is extremely low in the deoxidized zone. The ferrous iron values given in their report range from 1 to 5 x 10^{-4}% for the gray sediment matrix. Also, the gray matrix of the deoxidized zone yielded low ferric oxide values. These values were in the range of 0.3 to 0.6%. However, the free iron-oxide content of the vertical tubules or pipestems, which were segregated in the deoxidized zone, varied from 9 to 26%. Free iron oxide values of 0.4% were reported for the gray sediment matrix in samples from deoxidized loess from east-central Iowa (Fenton, 1966).

Laboratory data reported for the unoxidized zone indicates that ferrous iron is present. Daniels et al., (1961) reported ferrous iron values ranging from 4 x 10^{-4} to 2.3 x 10^{-1}%. Free iron oxide values from the same samples varied from 0.1 to 0.6%. These writers also reported that the color of the unoxidized sediment changed upon exposure to the air. Free iron oxide values of 0.4% were reported for the matrix of unoxidized loess from east-central Iowa (Fenton, 1966, p. 201).

<u>Oxidation zones in loess</u>

The oxidation model formulated by Van Hise (1904) contained an oxidized phase and a deoxidized phase. This was a basic oxidation-reduction concept. Through the years Van Hise's model (1904) has gradually been modified to fit field descriptive criteria.

The unoxidized state has been utilized to describe those sediments which have not experienced any weathering and have not been exposed to oxygen. This criterion has been especially useful for describing the oxidation state of till deposits (Kay and Apfel, 1929, p. 162; Ruhe, 1954; Ruhe, 1969a). Recently, the unoxidized zone has been introduced to describe the basal increment of loess in east-central Iowa (Fenton, 1966, p. 65; Ruhe et al., 1968, p. 19; Ruhe, 1969a, p. 46; Vreeken, 1972, p. 137).

The deoxidized state of oxidation has been utilized to characterize the portion of the matrix which is dominated by gray and light gray colors.

Kay (1916a) first used the term deoxidized in his description of gumbotil: "Gumbotil is, therefore, a gray to dark colored, thoroughly leached nonlaminated, deoxidized clay,..." In a later paper (Kay and Pearce, 1920) Kay apparently had reconsidered the use of the term deoxidized for sediments having gray matrices. In that paper (p. 94) gumbotil was described as being dark in color with the dominant gray color being mottled with brown and reddish tints. They state (p. 122) that the gray colors are due to the color of the colloidal clays and these colors are strong enough to mask the reddish-yellow color of oxidized iron. They conclude by stating:

> This doubtless is responsible for the belief held by some persons that the iron in the gumbotil is deoxidized or reduced, a condition which could hardly be possible in the presence of the oxygenated soil solution.

Subsequent to that paper Kay and his associates refrained from using the term deoxidized for description of weathering zones, except for one occasion. In describing the contrasting yellow and gray phases of loess in Johnson County, Kay and Graham (1943, p. 170) stated that the gray matrix was deoxidized.

Ruhe (1954) described a deoxidized zone in the loess from southwestern Iowa. This zone was defined as having a gray matrix with reddish-brown iron oxides segregated into tubules and concretions.

In a paper published the following year (Ruhe et al., 1955) a more detailed color description of the loessial deoxidized zone was presented. In that paper the writers concluded that deoxidized zones reflect relicts of pre-existing environments where the water table and zone of saturation stood higher on the landscape than at present.

A subsequent paper was published in 1956 (Ruhe and Scholtes, 1956) in which loessial deoxidized zones were again discussed:

> Apparently the iron oxide throughout the deoxidized zone is in a reduced state. Reoxidation of iron has occurred only where access to better aeration is available such as root tubules (pipestems) and concretions. The zones are massive gleyed horizons, and conform to the accepted concept of a G horizon. Gleyed horizons are considered to be zones of intense reduction that are characterized by the presence of ferrous iron that was developed by saturation of a zone with water in the presence of organic matter.

Data for deoxidized zones in both loess and till samples from western and central Iowa were reported by Daniels et al., (1961). Their results indicate that the chemical reduced iron is extremely low in the deoxidized zone. The ferrous iron values given in their report range from 1 to 5 x 10^{-4}% for the gray sediment matrix. These values are comparable to those ferrous iron values determined for the oxidized zones. On the other hand, in the deoxidized zone the segregated free iron oxides ranged in value from 9 to 26%. These results indicate that the dominant chemical state of the iron in the deoxidized zone is free iron oxide, Fe_2O_3. The sediment matrix is void of oxidized coatings on the particle grains. The gray and light gray hues are the color of the bare silt-sized grains.

Ruhe and his associates have continued to use the deoxidized term to imply "relict gleying" (Hall, 1965; Daniels and Jordan, 1966; Fenton, 1966; Ruhe et al., 1967; Ruhe et al., 1968; Ruhe, 1969a; Allen, 1971; Vreeken, 1972; Worcester, 1973).

An oxidation terminology dilemma has developed. The oxidation state of iron has been inferred, based on the matrix color of the sediments. This is the case for both deoxidized sediments and unoxidized characterization of loess deposits. The deoxidized and unoxidized characterization of loess deposits developed from studies conducted in Iowa. Possibly, a new set of terminology, based on hues, chroma, and values, should be formulated to adequately characterize oxidation states of unconsolidated sediments.

Chemical analysis in weathering zones

Organic carbon   Organic carbon (OC) has been tested as a criterion for identification of weathering zones in loess deposits (Allen, 1971, p. 81). However, due to the low organic carbon values present in the weathering zones OC cannot be relied upon to differentiate weathering zones or boundaries. Organic carbon values of 0.10 to 0.20% have been reported in loessial oxidized and deoxidized zones from western Iowa (Daniels and Handy, 1959; Ruhe, 1969a, p. 49; Allen, 1971, p. 63; Ruhe, Miller, Vreeken, 1971). In other areas of Iowa OC values for the oxidized, deoxidized, and unoxidized zones have not been reported (Hall, 1965; Fenton, 1966; Vreeken, 1972). Accumulations of OC in these weathering zones have not been reported because the investigators did not perform detailed analysis for OC on samples from these zones. Determination of OC for samples from the thick deoxidized and unoxidized zone in the loess of eastern Iowa may be an important factor is assessing the coloration of these zones.

Phosphorus   Phosphorus (P) in soils and weathering zones occur in inorganic and organic forms. Together, these two forms constitute total phosphorus (TP). Inorganic forms may be divided into five major fractions (Chang and Jackson, 1957). The weathering order from the least resistant to the most resistant is: calcium phosphates (Ca-P), aluminum phosphates (Al-P), iron phosphates (Fe-P), reductant soluble phosphates (Red-P), and occluded phosphates (Occ-P). The distribution of these fractions in the soil material reflect the degree of chemical weathering which has occurred (Chang and Jackson, 1958).

Parent materials are the sole source of phosphorus in weathering zones, other than a minute amount contained in rainwater (Black, 1968, p. 559). The low solubility of phosphorus in soils and parent materials causes it to be highly stable. The phosphorus solubility diagram constructed by Lindsay and Moreno (1960) provides an insight to the chemistry of soil phosphorus. Apatite accounts for most of the P in unweathered parent material. Fluorapatite is the most stable form of apatite but indications are that in most samples less than half of the P can be accounted for as fluorapatite (Black, 1968, p. 566). Therefore, the quantity of weathered P in the soil and parent materials is dependent on the weathering of apatite (Smeck, 1973).

It is important to note that pure apatite can be dissolved in a 1-hour extraction with 0.5N HCl solution (Chang and Jackson, 1957). However, Williams, Syers, and Walker (1967) reported that in a soil a second 4-hour extraction with 1.0N HCl solution removed additional Ca-P. This was apparently due to the occurrence of apatite inclusions within primary minerals which were in the soil material.

Smeck (1973) has summarized the relationship of P to the weathering processes which occur in soil and parent materials. Briefly, to summarize, Smeck (1973) states that the pH of the soil material must be 7.5 or less before P is released. The soluble P is then utilized by plants, leached, or precipitated as Ca-, Al-, or Fe-phosphate. Since the parent material is the only source of P in the soil, once the P is weathered from apatite, the phosphate in the weathering profile is dependent on the solubility of the Ca-, Al-, and Fe-phosphates. He concludes that P is most readily susceptible to transloca-tion at pH 7.0. At pH values below 7.0, P is dependent on the solubility of Al- and Fe-phosphates. At pH values above 7.0 P is dependent on the solubility of Ca-phosphates.

In the weathering profile the transformation of acid-soluble phosphates to other inorganic forms of P is the re-sult of weathering. Calcareous materials in the unweathered profile have a narrow buffered pH range of 7.8 to 8.2 (Krum-bein and Garrels, 1952). Therefore, the first stage of solu-tion, the carbonate solution, must occur at a pH of 7.8 or less. Chang and Jackson (1958) showed that in the P weather-ing sequence the Ca-phosphates were least stable. Runge, Walker, and Howarth (1974) have summarized P studies conducted for a chronosequence of soils on four different parent materi-als. They concluded that the predominant form of P in un-weathered parent material was Ca-phosphate. With increasing weathering the proportion of Ca-phosphate decreased.

One test for the intensity of weathering of parent materials would be the determination of Ca-phosphate distribution in the weathering zone of unconsolidated sediments. Runge et al. (1974) identified incipient weathering zones and paleosols in leached loess deposits of New Zealand by extracting Ca-phosphates from samples.

Soils

This study is concerned with the characteristics of the well to moderately well drained loess-derived Mollisols which occur on the primary and secondary divides in Cedar and Scott counties, Iowa.

Historical development

In the early history of the soil survey of the United States, series differentiations were based on broad geological regions and on the suitability for crop production (Whitney, 1909). All of the dark-colored upland soils of the prairie region were included in the Marshall series. The separation of the loess and till-derived soils and the subdivision of the loessial parent material zones have recently been summarized (Fenton, 1966; Huddleston, 1969).

The soil survey report of Scott County, Iowa (Stevens, Smies, and Espe, 1917) describes the dominant dark-colored surface, loess-derived soil as Muscatine silt loam and Muscatine silt loam, rolling phase. This series accounted for 52.1% of the total acreage within the county. The Muscatine series was first mapped and described in the soil survey report of Muscatine County (Hawker and Johnson, 1916).

In Scott County the Muscatine series was mapped on nearly level to gently rolling topography. The series was mapped extensively in the west and northwestern area of the county. The Muscatine soils were described as a dark-brown silt loam surface averaging 15 inches in thickness. A slightly lighter, more compact silt loam was subjacent to the surface horizon. At a depth of 20 to 24 inches the Muscatine series was described as having a yellowish or faintly mottled gray and yellow silty clay loam which extended to a depth of 36 inches or more.

The soil survey report of Cedar County, Iowa (O'Neal and Gray, 1921) indicates that the dominant upland loess-derived soils were Muscatine silt loam and Tama silt loam. These two series accounted for 29.8 and 26.3%, respectively, of the total acreage mapped in the county. The Tama series was first named and described in the soil survey report for Black Hawk County (Tharp and Harper, 1919).

In the Cedar County soil survey report (O'Neal and Gray, 1921) the Muscatine series was described as having a brown to dark brown silt loam surface which was 17 to 20 inches in thickness. The subsoil was described as consisting of a light brown to yellowish brown heavy silt loam to silty clay loam grading, at 24 to 30 inches, into a light brown to yellowish-brown silty clay loam to silty clay. The subsoil, below 30 inches, was mottled with colors of brown, gray, and yellow. This series was described as occurring on the crests of the broader ridges and divides.

In the same report (O'Neal and Gray, 1921) the Tama series was described as being characterized by a brown to dark brown silt loam surface which was 10 to 15 inches in thickness. The subsoil was characterized by a light brown to yellowish brown heavy silt loam which graded into a yellowish brown silty clay loam. Occasional faint gray mottles were noted in the lower subsoil (O'Neal and Gray, 1921). The Tama series was described as occupying the moderately rolling slopes and occurring in a position intermediate between the Muscatine soils and the bottomland topography.

A modern study (Ryan, Smith, and Riecken, 1959) of the Muscatine series in Muscatine County indicates that the diagnostic properties defined for the original Muscatine soils (Hawker and Johnson, 1916) are now included within the range of the Tama soils.

Fenton (1966) has recently summarized the history of the Tama series. He provided a detail review of the studies conducted in Iowa which concern this soil series.

Soil associations

The majority of the geographic area studied and discussed in this dissertation is included within the boundaries of the Tama-Muscatine and Dinsdale-Tama soil associations (Figure 3).

Both the Tama and Dinsdale soils are well drained. The series differential concerns the loess thickness on which these soils are formed. The Tama soils occur where the loess thickness is greater than 40 inches. The Dinsdale soils are located on landscapes where the loess thickness ranges between 20 and 40 inches (Oschwald et al., 1965). These landscapes are termed thin loess areas. Therefore, within the study area, the well drained Mollisols which have formed from loess are now included within the Tama or Dinsdale series (Oschwald et al., 1965). The Muscatine soils are classified as somewhat poorly drained (Oschwald et al., 1965). The thin loess equivalent of the Muscatine soil is the Klinger series.

Soil models

The use of models for a framework to guide investigation and for systematizing results have long been used in pedology. Most models are influenced by Jenny's (1941) state factor equation of soil formation. In Iowa, Corliss (1958) formulated models for field observations based on natural drainage, native vegetation, and profile textural development. The soil series of the Tama-Muscatine soil association area of eastern Iowa are arrayed by biosequence and natural drainage classes in Table 2.

Tama soils within the study area

During the past 25 years several investigators have questioned whether the Tama soils in Cedar and Scott counties are

Table 2. Soil series of the Tama-Muscatine soil association area arrayed by biosequence and natural drainage class

	Toposequence		
Biosequence	Well	Somewhat-poorly	Poorly
Prairie	Tama Typic Argiudoll	Muscatine Aquic Argiudoll	Garwin Typic Haplaquoll
Transitional	Downs Mollic Hapudalfs	Atterberry Udollic Ochraqualfs	Walford Mollic Ochraqualfs
Forest	Fayette Typic Hapludalfs	Stronghurst Aeric Ochraqualfs	Traer Typic Ochraqualfs

analogous to the Tama soils in east-central Iowa (Figure 3). Smith, Allaway and Riecken (1950, p. 169) noted that extensive areas of Tama soils in eastern Iowa contained B horizons having relict characteristics which would be associated with Alfisols. These soils were characterized by an increase in the degree of development of the structural aggregates in the B horizon and moderate-to-heavy coatings of light gray silt grains on the structural aggregates. Simonson, Riecken, and Smith (1952, p. 54) noted that some of the Tama soils in Cedar and Scott counties have properties similar to the transitional soils of the well drained biosequence. Arnold (1963, p. 108) concluded that the Tama soils in Scott and Cedar counties often have mottling in their subsoils and should be classified as moderately well drained soils. He showed that 38 of 50, or 76%, of the profiles sampled in the Cedar-Scott County area contained grainy gray coats or silans within the B horizon. These figures compared to 20 of 58, or 34.5%, of the Tama-Muscatine profiles from east-central Iowa, which had gray ped coatings in the B horizon. Arnold (1963; Arnold and Riecken, 1964; Arnold, 1965) concluded that the development of grainy gray coats on the ped surfaces were the result of the influence of relict forest vegetation.

In Cedar County, Iowa, field mapping by the Cooperative Soil Survey commenced in the fall of 1969. Early in the mapping program, soil mappers reported a large areal distribution of well drained to moderately well drained upland soils, with mollic epipedons, which contained grainy gray ped coatings in their subsoils.

Several specific characteristics were associated with these soils.[1] These soils had mollic colors to a depth of approximately 15 inches. The B horizons were essentially free of low chroma mottles to a depth of 36 inches or more. However, at a depth of 24 to 27 inches, ped coatings of grayish brown (2.5Y 5/2) were evident on the structural aggregates. Other characteristics included: (1) the surface horizons were not as thick or as dark as the modal Tama soils associated with stable landscape positions, (2) textures within the surface material were silt loam, in lieu of silty clay loam, with some evidence of grainy coats on the structural aggregates, (3) the B2 horizons contained stronger developed structure and more degradation of the ped surfaces, as evidenced by the presence of grainy silt coats, than typically found in the modal Tama soils, and (4) the B/A clay ratios were higher than normally found in the modal Tama soils. On the basis of these characteristics, which could be readily recognized in the field environment, soil survey leaders decided to separate these soil areas from soils which met the requirements of the Tama mapping units.

The field mapping in Cedar County was concluded in the

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[1]Information from Cedar County Cooperative Soil Survey files at the Ames, Iowa, Soil Survey Office. 1971.

spring of 1974. A total of 374,402 acres are within the confines of Cedar County. Approximately 66,200 acres (17.7%) were mapped and designated as meeting the requirements of the Tama mapping units.[1] An additional 1,340 acres (0.36%) were identified and mapped as a grainy coat taxadjunct of the Tama mapping units.

Several landscape features which are characteristic of the study area were noted during the initial field work of the Cooperative Soil Survey. The east-central region of Cedar County is characterized by upland landscapes with hillslopes having long, gently sloping gradients of less than 9% and a minimum of stream dissection. These features are in contrast to the typical Kansan drift plain topography which has been defined for this area (Ruhe, 1969a). In fact, these features are comparable to the topographic features reported as being characteristic of the Iowan erosion surface area (Ruhe et al., 1968).

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[1]Schermerhorn, E. J., Iowa City, Iowa. Information from field files. Private communication. 1974.

METHODS AND PROCEDURES

This study consists of an investigation of the geologic materials and ground soils and their interrelationships in the Tama-Muscatine soil association area of Cedar and Scott counties and the Dinsdale-Tama soil association area of Cedar County. This section describes: (1) how coreholes are located and designated, (2) weathering zone and surface terminology, (3) design and geographic location of the study areas, and (4) laboratory procedures used in the investigation.

Terminology

Coreholes are identified by a prefix designating the county number. The prefix is followed by an alphic designator for the surname of the investigator and a two-field numeric designator for the corehole number. The latter values were assigned by the chronological order in which cores were collected in the field. For example, core 16-M15 indicates that the core is from Cedar County and is the fifteenth in the series collected by the author.

One series of coreholes are identified with an additional alphic suffix. These coreholes, 16-M7A through M7K, are part of the Bennett transect. These cores represent equal spaced sites collected along a hillslope transect on the loess-mantled Iowan surface.

Weathering zone terminology follows the standard criteria which has been most recently summarized by Fenton (1966) and Ruhe (1969a, p. 46-49).

Quarternary depositional and erosional units and surfaces follow the time-stratigraphic terminology summarized by Ruhe (1969a).

A listing of common abbreviations used in this dissertation are given in Table 3.

Soil colors are described according to Munsell color charts. Unless stated, all soil colors are described for moist soil conditions.

Field Studies

The field investigation was conducted in three phases, each phase representing different geographic parts of the study area.

Reconnaissance traverse

A traverse consisting of a series of deep borings was made along a line extending parallel to the topographic divide of the Cedar and Wapsipinicon Rivers (Figure 2). This traverse was made for the purpose of mapping the areal distribution of parent materials and collection of ground soils. Adjacent to this traverse a series of borings was made to supplement the information determined from the traverse cores. These cores include coreholes 16-M20, M21, M22, and M24 in Cedar County and coreholes 82-M1 and M2 in Scott County (Figure 2).

Table 3. Common abbreviations used in this dissertation for weathering zones, depositional or erosional units and surfaces

Abbreviation	Explanation
O & L	Oxidized and leached
O & U	Oxidized and unleached
D & L	Deoxidized and leached
D & U	Deoxidized and unleached
U & U	Unoxidized and unleached
WL	Wisconsinan loess
Band	Organic carbon band
IESC	Iowan erosion surface complex
BWP	Basal Wisconsinan paleosol
LSP	Late Sangamonian paleosol
YSS	Yarmouthian-Sangamonian surface
YSP	Yarmouthian-Sangamonian paleosol
TYSP	Truncated Yarmouthian-Sangamonian paleosol
KT	Kansan till

Bennett transect

An area located in sections 12 and 13, T.80N., R.1W., was selected for a detailed transect study (Figures 2, 4 and 5). This transect starts on the summit of a paha, in sec. 12, and traverses southward into sec. 13. In sec. 13 the transect was established along the descending hillslope of the paha. At

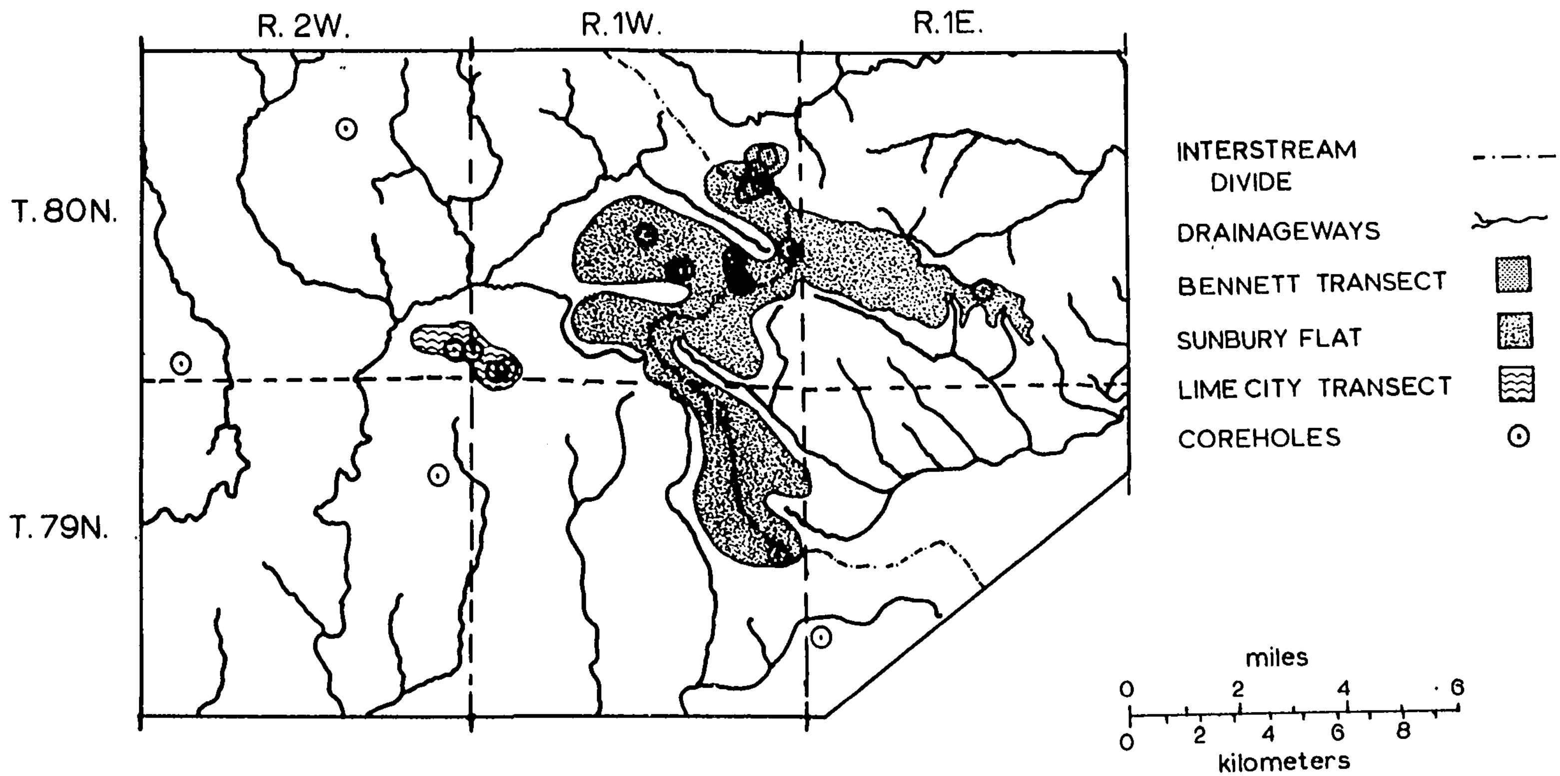
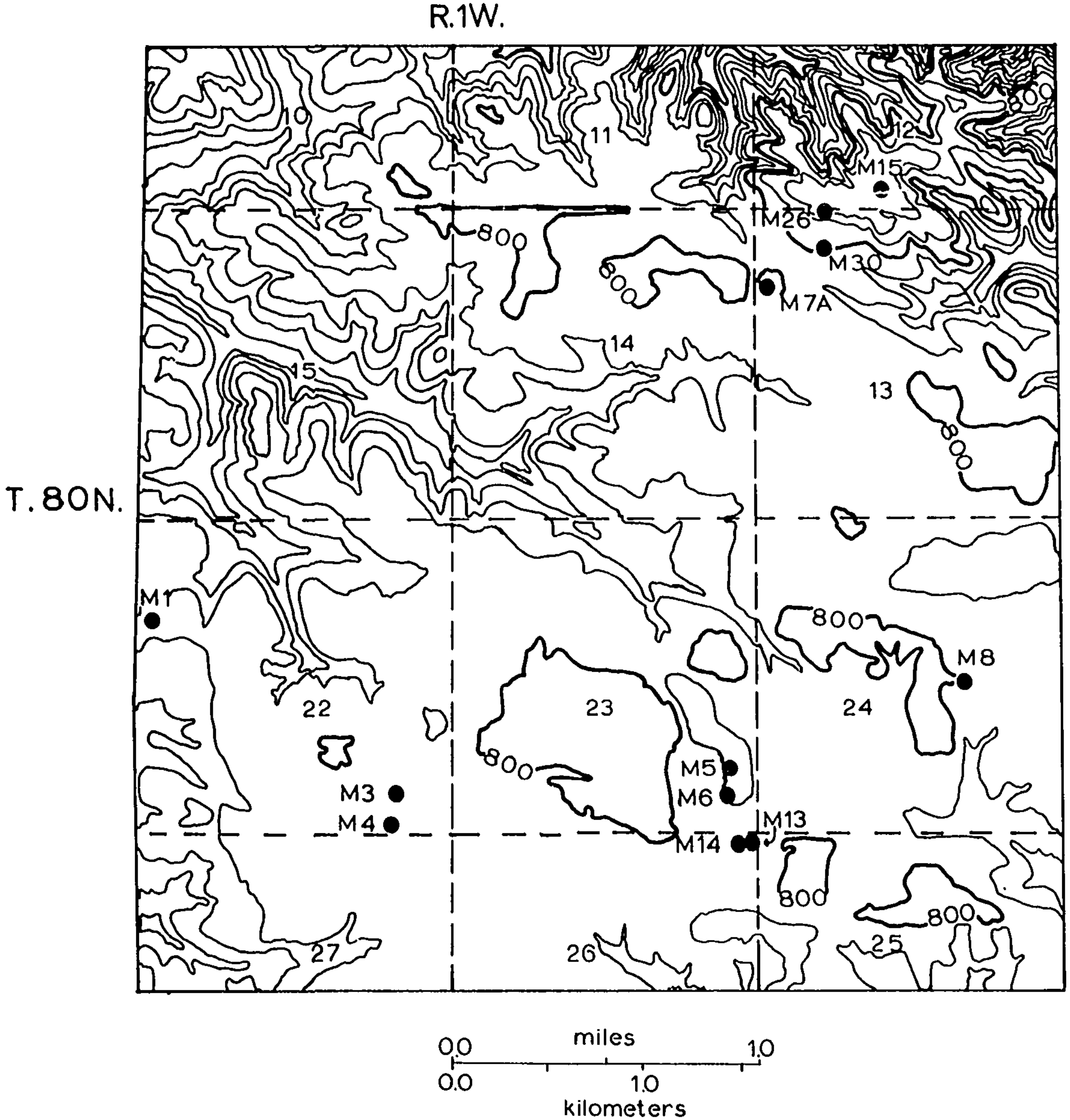


Figure 4. Map showing the general location of the Bennett transect, the Sunbury Flat, and the Lime City transect in Cedar County

Figure 5. Topographic map of a portion of the Sunbury Flat area and associated coreholes. Coreholes of the Bennett transect are located in sections 12 and 13. Contour interval is 10-foot


R.1W.
T. 80N.
10
11
12
13
14
15
22
23
24
25
26
27
800
M1
M3
M4
M5
M6
M7A
M8
M13
M14
M15
M26
M30
miles
0.0
1.0
kilometers
0.0
1.0

the toeslope the transect was aligned to the southwest, and extended along a line which bisects the topographic divide of the Cedar-Wapsipinicon River watersheds. The transect continues for approximately 1100 feet southwesterly terminating on the well drained upland landscape. Coreholes in this area include cores 16-M7A through M7K, M15, M26, M27, M28, M29, M30, M31, and M32 (Figure 4).

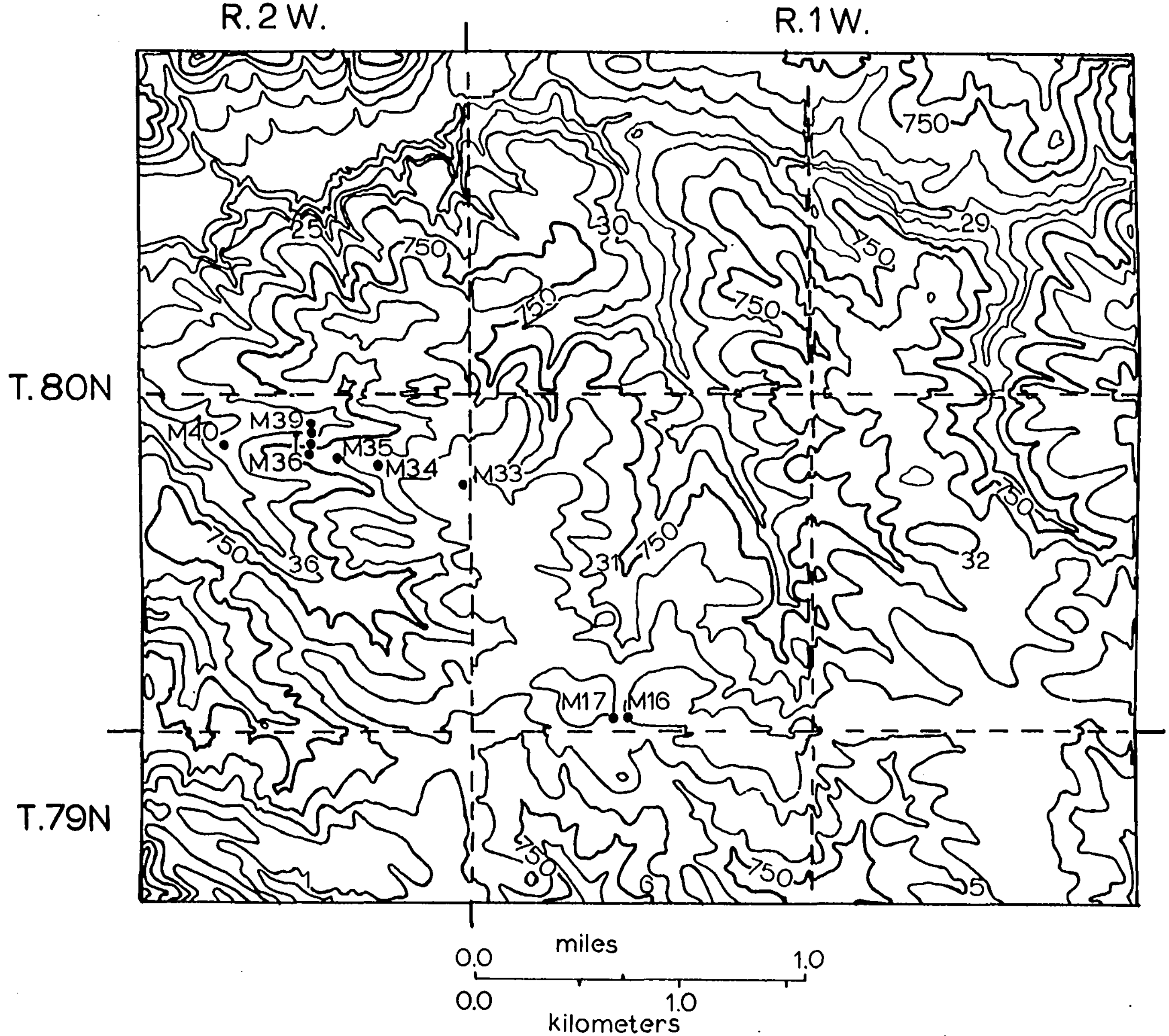
The purpose of this transect was to: (1) identify the paleogeomorphic surfaces occurring on and adjacent to a paha, (2) reconstruct the geologic erosional and constructional history of the area, (3) investigate the soil parent materials, and (4) identify physical and chemical properties of the ground soils across contrasting slope and drainage classes.

Lime City transect

An area in sec. 31, T.80N., R.1W., and sec. 36, T.80N., R.2W., which is normal to the reconnaissance traverse was selected for detail study (Figures 4 and 6). The purpose for studying this transect was: (1) observe stratigraphic and soil parent material relationships and compare these relationships to the soil-parent material system found in transects and coreholes located on the stable primary divide, and (2) observe physical and chemical properties of the ground soils formed on secondary and tertiary interfluves within a major watershed.

The transect is aligned to the northwest and crosses from

Figure 6. Topographic map showing the location of coreholes in the Lime City transect. Contour interval is 10-foot


R.2W.
R.1W.
T.80N
T.79N
750
25
29
30
31
32
36
1
5
6
M40
M39
M36
M35
M34
M33
M17
M16
miles
0.0
1.0
0.0
1.0
kilometers

the stable upland flats in sec. 31 onto the axis of a west facing interfluve in sec. 36. Coreholes were made on the summit of the interfluve across a distance of 0.5 miles. At corehole M36 (Figure 6) a transect was made along the north facing hillslope.

Coreholes made in the Lime City transect include cores 16-M16, M17, and M33 through M40.

<u>Site locations</u>

The corehole identification and site location as well as surface elevation, loess thickness, sand zone thickness, and native vegetation and drainage class of the associated ground soil are listed in Table 4.

<u>Collection of cores</u>

The deep borings for collection of stratigraphic parent materials and associated ground soils were made with a truck-mounted Giddings hydraulic probe and/or a hand-operated soil probe utilizing vertical extensions. The gross morphology of the stratigraphic units and weathering zones were described in the field concurrent with the collection of the cores. The cores were placed in cardboard core storage boxes and stored in a freezer prior to laboratory preparation.

The elevations of sites from which the cores were collected were obtained from USGS 7½-minute topographic maps. Field checked elevations annotated on the topographic maps were identified and located in the field. Sample sites were

Table 4. Core number, location, surface elevation, loess and sand zone thickness, and presence or absence of paleosol for stratigraphic profiles, native vegetation and drainage class of the associated ground soil for coreholes collected in Cedar and Scott counties, Iowa

Corehole number	Location	Surface elevation (ft)	Loess thickness (ft)	Sand zone thickness (ft)	Paleosol on till	Native vegetation and drainage class
16-M1	NW¼ sec. 22, T.80N., R.1W.	798.0	14.0	2.8+		Prairie; mod. well
16-M3	SE¼ sec. 22, T.80N., R.1W.	799.0	10.8	4.7		Prairie; well
16-M4	SE¼ sec. 22, T.80N., R.1W.	794.0	12.1	0.0		Transitional; SW poorly
16-M5	SW¼ sec. 23, T.80N., R.1W.	802.0	11.7	0.0		Prairie; well
16-M6	SW¼ sec. 23, T.80N., R.1W.	804.0	11.7	3.2+		Prairie; well
16-M7A	NW¼ sec. 13, T.80N., R.1W.	803.8	12.8	5.7		Prairie; mod. well
16-M8	SW¼ sec. 24, T.80N., R.1W.	803.0	13.5	5.2		Prairie; well
16-M9	SE¼ sec. 13, T.79N., R.1W.	762.0	10.1	6.5		Transitional; SW poorly
16-M10	NE¼ sec. 2, T.79N., R.1W.	779.0	12.8	4.2		Prairie; SW poorly
16-M11	NE¼ sec. 25, T.81N., R.2W.	841.0	16.5	8.5		Prairie; SW poorly
16-M12	SE¼ sec. 11, T.81N., R.2W.	856.0	12.8	5.1		Prairie; well
16-M13	NW¼ sec. 26, T.80N., R.1W.	794.0	8.0	0.0		Transitional; poorly
16-M14	NE¼ sec. 26, T.80N., R.1W.	795.5	10.8	0.3		Transitional; poorly

Table 4. (Continued)

Corehole number	Location	Surface elevation (ft)	Loess thickness (ft)	Sand zone thickness (ft)	Paleosol on till	Native vegetation and drainage class
16-M15	SW¼ sec. 12, T.80N., R.1W.	830.9	25.7	0.0	X	Transitional; SW poorly
16-M16	SW¼ sec. 31, T.80N., R.1W.	781.0	13.3	7.4		Prairie; well
16-M17	SW¼ sec. 31, T.80N., R.1W.	776.0	12.3	4.9		Transitional; SW poorly
16-M18	SE¼ sec. 28, T.82N., R.2W.	860.0	5.6	3.5		Prairie; well
16-M19	NW¼ sec. 12, T.81N., R.2W.	894.0	29.7	0.0	X	Prairie; well
16-M20	NE¼ sec. 30, T.81N., R.2W.	834.0	17.2	6.4+		Prairie; well
16-M21	NE¼ sec. 10, T.80N., R.2W.	806.0	15.2	0.0		Prairie; well
16-M22	SE¼ sec. 31, T.80N., R.2W.	804.0	28.0[a]	2.2	X	Transitional; well
16-M23	SE¼ sec. 12, T.82N., R.3W.	840.0	2.8	0.0		Prairie; SW poorly
16-M24	SW¼ sec. 12, T.79N., R.2W.	786.0	25.2	0.0	X	Prairie; SW poorly
16-M25	NW¼ sec. 13, T.80N., R.1W.	793.4	12.9	0.0		Prairie; poorly
16-M26	NW¼ sec. 13, T.80N., R.1W.	825.0	23.5[a]	2.9	X	Prairie; well
16-M27	NW¼ sec. 13, T.80N., R.1W.	818.0	18.4[a]	0.3	X	Prairie; well

[a]Loess thickness includes strata of intercalated sands.

Table 4. (Continued)

Corehole number	Loaction	Surface elevation (ft)	Loess thickness (ft)	Sand zone thickness (ft)	Paleosol on till	Native vegetation and drainage class
16-M28	NW¼ sec. 13, T.80N., R.1W.	811.3	22.3[a]	5.2	X	Prairie; well
16-M29	NW¼ sec. 13, T.80N., R.1W.	814.6	14.1[a]	1.6	X	Prairie; well
16-M30	NW¼ sec. 13, T.80N., R.1W.	806.6	17.1	3.4		Prairie; well to SW poorly
16-M31	NW¼ sec. 13, T.80N., R.1W.	803.2	16.8	0.0		Prairie; SW poorly
16-M32	NW¼ sec. 13, T.80N., R.1W.	800.6	13.9	3.9		Prairie; SW poorly
16-M33	NE¼ sec. 36, T.80N., R.2W.	772.0	12.0	0.0		Prairie; SW poorly
16-M34	NE¼ sec. 36, T.80N., R.2W.	766.0	9.0	0.0		Prairie; well
16-M35	NE¼ sec. 36, T.80N., R.2W.	760.0	9.7	0.0		Prairie; well
16-M36	NE¼ sec. 36, T.80N., R.2W.	756.0	9.2	0.0		Prairie; well
16-M37	NE¼ sec. 36, T.80N., R.2W.	749.0	11.5	0.0		Prairie; well
16-M38	NE¼ sec. 36, T.80N., R.2W.	742.0	12.4	0.0		Prairie; well
16-M39	NE¼ sec. 36, T.80N., R.2W.	738.0	10.2	0.2		Prairie; well
16-M40	NW¼ sec. 36, T.80N., R.2W.	732.0	9.7	4.2		Prairie; well
16-M41	NW¼ sec. 9, T.82N., R.4W.	888.0	4.3	2.0		Prairie; well
82-M1	NW¼ sec. 30, T.79N., R.1E.	745.0	10.0	0.0		Prairie; well
82-M2	NW¼ sec. 27, T.80N., R.1E.	795.0	12.0	0.0		Prairie; well

tied to these elevations by measurement with an engineering transit or by map inspection and interpolation.

Morphological descriptions

Morphological descriptions, the location and elevation of each core, and associated laboratory data are presented in Appendices A and B.

Laboratory Studies

Samples analyzed in the laboratory were removed from the freezer, thawed, described in terms of standard soil nomenclature (Soil Survey Staff, 1951), subsampled, and the subsamples were placed in plastic lined paper bags. The paper bags were placed on storage shelves and the samples were air-dried. Samples were crushed and passed through a round hole 2-mm sieve. The samples were separated into > 2-mm and < 2-mm particle sizes. The percentage > 2-mm, if any, was determined on a dry-weight basis.

Particle-size analysis

Particle-size distribution was determined by the pipette method (Kilmer and Alexander, 1949). A calgon dispersing solution, 38 g of commercial calgon and 8 g of sodium carbonate brought to a volume of 1 liter with distilled water, was used to disperse the soil sample. The sand component, > 62 μ, was removed by wet sieving through a 230 mesh sieve (U.S. series equivalent) as the remaining suspension was poured into a 1 liter graduated cylinder for subsequent pipette analysis. Pipetting of the silt and clay fractions were made in accordance with the Wentworth (1922) scale as modified by Ruhe (1969a, p. 30) at settling times calculated from the nomographs of Tanner and Jackson (1947). The 32 to 62 μ fraction was calculated by substracting the sum of the other fractions from 100%. The five fractions of the sand component, 62 to 2000 μ, were determined on samples with > 2.0% sand by dry sieving the sand on a Cenco-Meinzer Sieve Shaker using 8-inch diameter sieves. Subsequent to the analysis, the geometric mean particle size was calculated for selected samples. To calculate the geometric mean, size fractions between 2 to 2000 μ were used. Samples having < 3.0% sand content were grouped as if all sand was in the very fine sand fraction, 62 to 125 μ. Justification for using the 2 to 2000 μ particle-size range for statistical analyses has been described in the literature (Soil Survey Staff, 1951, p. 205; Walker, 1966, p. 856; Whiteside, 1967). Laboratory error of the pipette method was estimated by analyzing 12 subsamples of a representative silt loam. The average of the 12 determinations of geometric mean was 19.9 μ and the standard deviation was 0.37 μ. In addition, the average percentage of < 2 μ clay was 29.29% with a standard deviation of ± 0.75% for 38 samples.

Soil pH

A Beckman Zeromatic pH meter was used on a 1:1.5 soil to water mixture. Soil suspensions were stirred three times following the addition of distilled water and then allowed to stand for 30 minutes. The pH meter was standardized with buffer solutions at pH 4.0 and 7.0.

Total carbon

Total carbon (TC) was determined by the Leco 70-second carbon analyzer following the procedure of Tabatabai and Bremner (1970). Samples weighing between 0.1500 to 0.3500 g were used. Replications were made of approximately every 12 samples. The instrument was calibrated by burning known amounts of carbon contained in standard samples obtained from the Laboratory Equipment Corporation (LECO).

Organic carbon

All solum horizons sampled in this study were noncalcareous. The value obtained for total carbon percentage was used as organic carbon (OC) percentage. The same procedure was used to obtain the percentage of organic carbon for samples in the leached zones of the weathering profile, if the pH was equal to or less than pH 7.2. The percentage of organic carbon for samples from unleached zones or from zones of pH 7.3 and greater was determined by calculating the difference between the percentage of total carbon and the percentage of total carbon contributed by carbonates. In this calculation the percentage of carbonate equivalent is multiplied by 0.12 and the difference between the product, if any, and the percentage of total carbon is interpreted as organic carbon.

Calcium carbonate equivalent

Calcium carbonate equivalent values were obtained by a modification of the gravimetric procedure outlined by Walker (1965, p. 393).

1. Approximately 10 ml of 4N HCl was added to an oven-dried, 50-ml Erlenmeyer flask fitted with a No. 1 rubber stopper. The flask with its acid contents was weighed to 10^{-4} g.

2. A soil sample weighing 0.4500 to 0.5500 g was added to the flask. The stopper was loosely set on the flask opening and the contents were gently swirled 3 or 4 times during the subsequent hour. When a constant weight was obtained the percentage of carbonate equivalent was calculated as described by Allison and Moodie (1965, p. 1387).

3. Two blank standards were run with each set of 20 samples for the purpose of obtaining a CO_2 vapor loss.

Available phosphorus

Bray 1 Available phosphorus, Bray 1 (AP1), was determined by a modification of the Bray and Kurtz (1945) procedure. In this modified procedure 1.50 g of air-dried soil was weighed and transferred to a 90-ml polypropylene tube. Three ml of distilled water was added to the sample and the phosphorus was extracted with 12 ml of solution containing 0.025N HCl and 0.03N NH_4F. This yielded a 1:10 soil-extracting ratio. The suspended sample was placed on a reciprocating shaker for 5 minutes. The sample was then leached through a Whatman No. 41 filter containing approximately 5 g of decolorizing carbon. If the filtrate was not clear it was immediately poured back through the filter. A 0.5 ml ammonium molybdate solution (36.125 g NH_4 molybdate and 750 ml HCl per liter containing 50 g H_3BO_3) was then added to the filtrate. The filtrate was treated with 0.5 ml of the reducing agent. The reducing agent contained 1 part reagent to 6.25 parts of distilled water. The reagent consisted of 1 g 1-amnio-2-naphthol-4-sulfonic acid with 2 g sodium sulfite and 58.5 g sodium pyrosulfite. This reagent was made in bulk quantities and ground to pass a 80-mesh sieve. Five to ten minutes after the reducing agent was added to the leachate the transmittance percentage was determined using a red filter at 600 mμ with a Bausch and Lomb Spectronic 20 spectrophotometer. A series of 9 reagent standards ranging from 5.0 ppm to 0.1 ppm (0.2195 g of potassium dihydrogen phosphate in distilled water diluted to 1 liter equals 50 ppm P) were used to prepare the standard curve.

<u>Bray 2</u> Available phosphorus, Bray 2 (AP2), was determined by the same procedure as AP1, except that the extracting solution contained 0.1N HCl and 0.03N NH_4F.

Extractable acidity

Extractable acidity (EA) or extractable H^+ was determined by the $BaCl_2$-triethanolamine I procedure as outlined by the Soil Survey Staff (1967) and modified by Richardson (1974, p. 51).

Cation exchange capacity

Cation exchange capacity (CEC) was determined with an ammonia electrode by the method described by Busenberg and Clemency (1973) as modified by Miller, Riecken, and Walter (1975). The procedure was:

1. Weigh a 300- to 400-mg sample of air-dried soil and transfer the soil to a 50-ml polypropylene, round bottom centrifuge tube. A series of 16 samples were run simultaneously.

2. Add 10 to 15 ml of 1.0N NH_4OAc solution which had been adjusted to pH 7.0 and allow the samples to stand at least 12 hours.

3. Each sample was placed in a 16-place head centrifuge and centrifugation occurred at 1500 rpm for 15 minutes. The supernatant was poured off and 15 to 20 ml of 1.0N NH_4Cl was added. Each sample was stirred for approximately 1 minute with a glass rod. The centrifuging, pouring off the supernatant, and stirring was repeated until a negative ammonium oxalate test for excess Ca was obtained.

4. Excess ammonium salts were removed by adding 15 to 20

ml of reagent isopropyl alcohol, stirring the sample, washing the sample by centrifuging, and pouring off the supernatant. Usually four cycles were sufficient for obtaining a negative response for excess Ca and ammonium salts.

5. Samples were transferred to a 90-ml polyethylene chemical container fitted with a screw-on cap by using exactly 50 ml of deionized distilled water. A 50-ml polyethylene syringe with a Luer-type adapter was used for the transfer of the sample from the centrifuge tube to the chemical container.

6. The chemical container was placed on a small magnetic stirrer motor and a stirring bar, 2.5 cm in length, was inserted in the suspension. Stirring was commenced and maintained at a constant level (a necessary condition) while measuring both samples and standards.

7. The electrode was immersed in the suspension at a 20 degree angle which precluded the entrapment of air bubbles under the concave tip. The gas sensing membrane was replaced at the start of each day (Miller et al., 1975) to minimize drift and slow response.

8. Following the immersion of the electrode, 0.5 ml of 10M NaOH solution was added to the suspended sample. The millivolt response was read when the electrode reached equilibrium. Generally, 2 to 4 minutes were required before the electrode reached equilibrium. Longer times were required for lower ammonia concentrations.

9. Standards were prepared weekly and stored in a cool, dark cabinet. Standards ranged from 10^{-1} to 10^{-4} M. Most soil samples fell within the 10^{-3} to 10^{-2} M range. With experience sample weights can be approximated to provide results in the 1×10^{-3} to 3×10^{-3} M range. This area of the curve provides optimum interpolation from the semi-logarithmic plots.

10. Two soil samples of known CEC were determined with each set of unknowns.

11. The concentration of ammonia released from the soil by the NaOH treatment was determined by plotting the NH_3 electrode potential, mv, versus the NH_3 concentration of the standards on 3 cycle semi-logarithmic paper. The CEC of the sample was calculated by the following equation:

$$\text{CEC} = \frac{(\text{Conc. } NH_3 \text{ in moles/liter})(50 \text{ ml } H_2O)}{\text{Air-dried sample weight, mg}}$$

RESULTS

This section is designed to report the results collected in the field and determined in the laboratory. The results are reported from the bottom up, stratigraphically. The section begins with a description of the nature of the bedrock surface and concludes with a report on the characteristics of the ground soils.

In this section the interpretation of the results are kept to a minimum. Interpretation of the results is in the discussion section. In some cases interpretations are made in this section. These cases are limited to those items which can be dealt with in this section and would serve no useful purpose for reintroduction in a subsequent section.

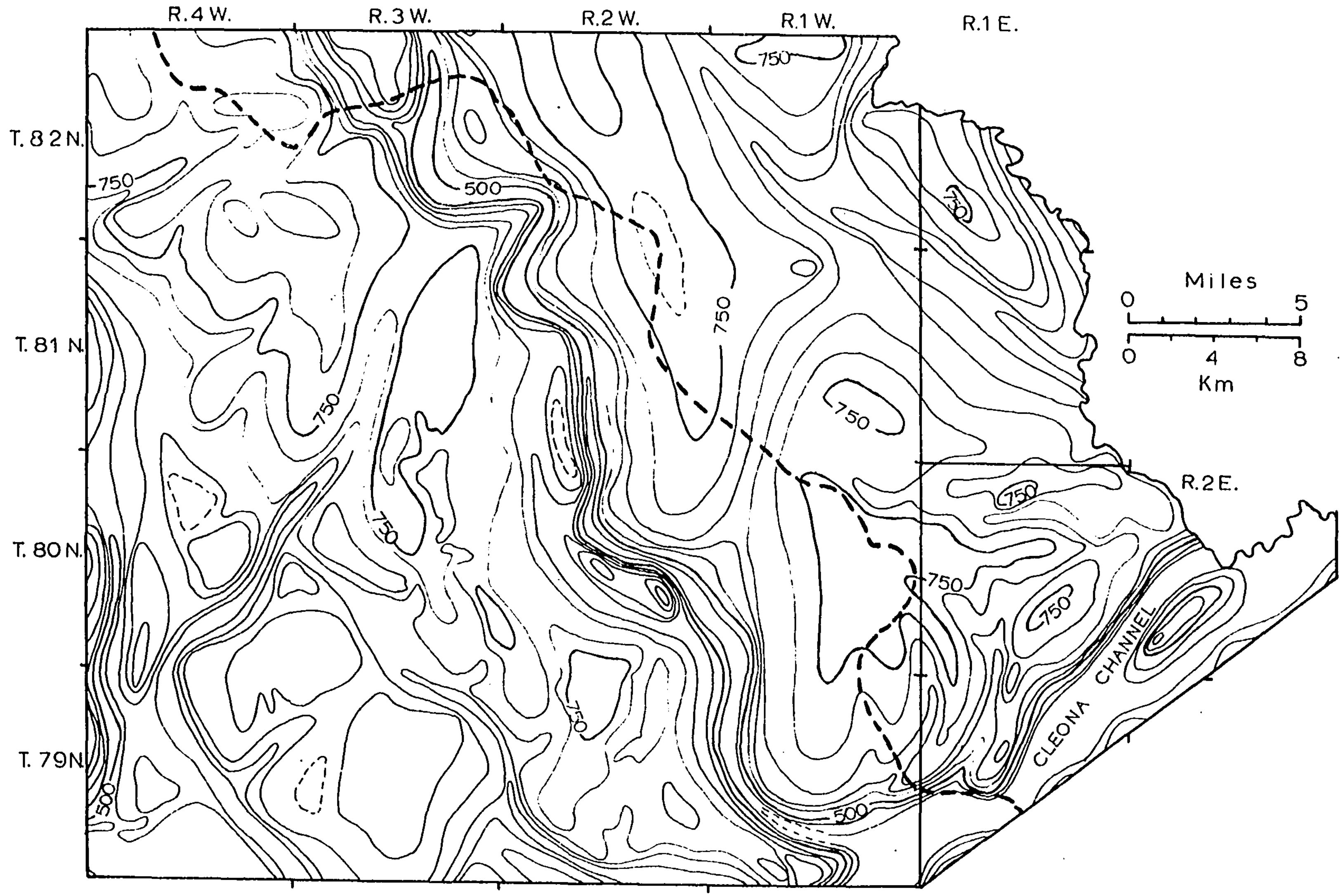
Bedrock Topography

Hansen (1972) has published a bedrock isopach map for eastern Iowa at the scale of 1:250,000 with a 50-foot contours. That map has been modified to present the bedrock isopach configuration of Cedar County and parts of adjacent Clinton and Scott counties (Figure 7).

Thickness of Unconsolidated Materials

At the time this dissertation was written quadrangle maps covering 7½ minutes of latitude and longitude were available for all of the area shown in Figure 6, with the following

Figure 7. Bedrock isopach map of Cedar County and portions of adjacent countries. Contour interval is 50-foot. Broken line indicates location of modern topographic divide between Cedar and Wapsipinicon Rivers (modified from Hanson, 1972)


R.4 W.
R.3 W.
R.2 W.
R.1 W.
R.1 E.
R.2 E.
T. 82 N.
T. 81 N.
T. 80 N.
T. 79 N.
750
500
Miles
0
5
0
4
8
Km
CLEONA CHANNEL

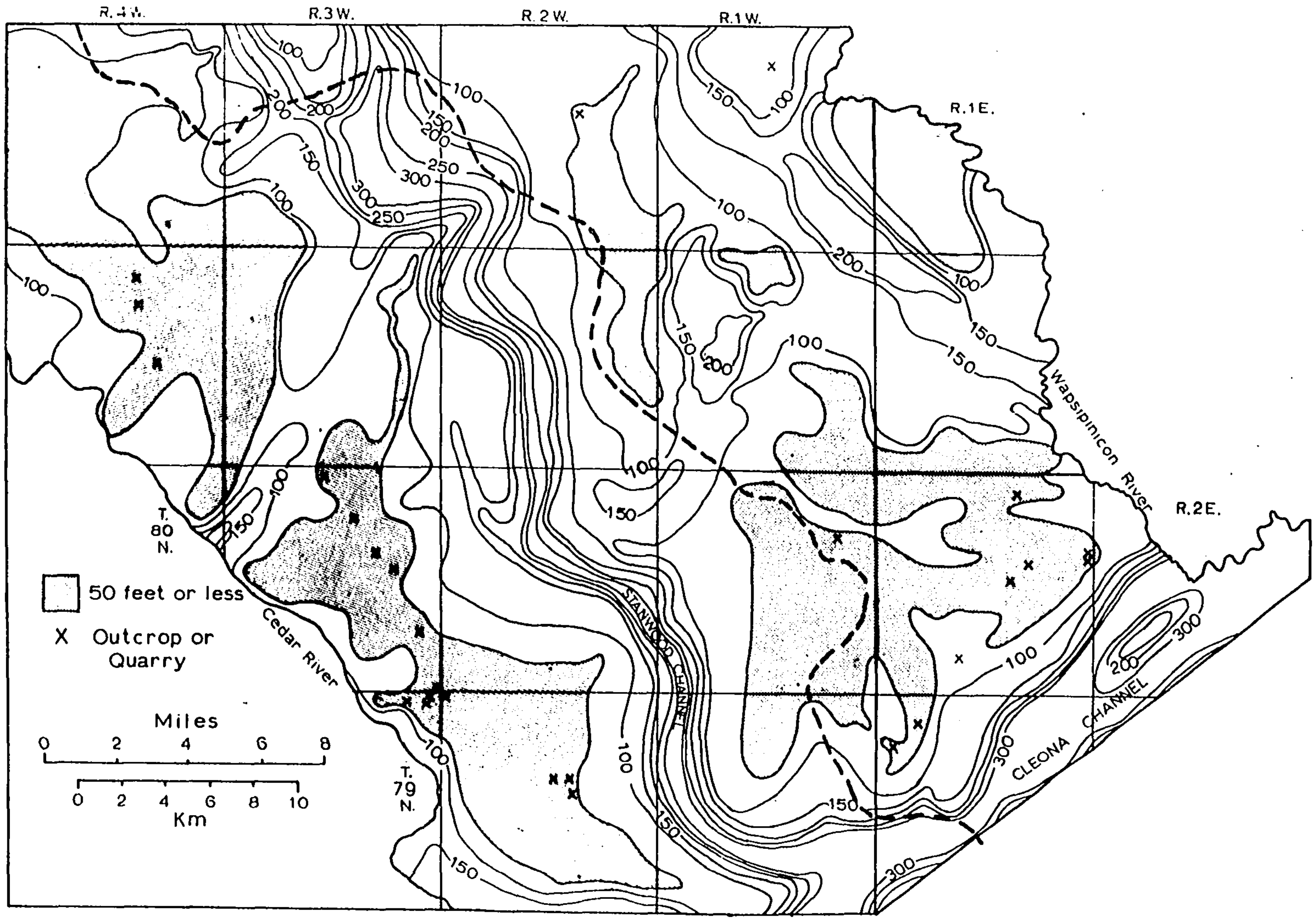
exceptions. A total of 32 sections in the northeast corner of Cedar County and approximately 5 sections in western Clinton County were not available. All 7½ minute topographic sheets for this area are marked with 10-foot contour intervals. In addition, many section corners have field checked elevations.

With this resource of information available, an isopach map of the thickness of unconsolidated materials was constructed (Figure 8). This map was constructed by determining the elevation of the bedrock surface at each section corner. The difference between the bedrock surface and the ground surface, determined from the respective topographic map, was plotted on Hansen's (1972) 1:250,000 bedrock isopach map. Contours were plotted resulting in the unconsolidated thickness isolith map (Figure 8).

These maps reveal that much of the modern Cedar-Wapsipinicon primary divide is underlain by a bedrock topographic high which is covered by less than 50 feet of Quaternary sediments. Another bedrock topographic high occurs along the east flank of the modern Cedar River Valley. Within the study area the Cedar River is not controlled by preglacial bedrock channels except in T.79N., R.2W. (Hansen, 1972). This area east of the Cedar River also is covered by less than 50 feet of Quaternary sediments.

Other locations within the study area having less than 50 feet of Quaternary sediments are within the boundaries of the

Figure 8. Isolith map of the study area showing the thickness of the unconsolidated sediments. Contour interval is 50-foot. Broken line indicates location of topographic divide between Cedar and Wapsipinicon Rivers


R.4W.
R.3W.
R.2W.
R.1W.
R.1E.
R.2E.
T. 82 N.
T. 81 N.
T. 80 N.
T. 79 N.
50 feet or less
X Outcrop or Quarry
Miles
0 2 4 6 8
0 2 4 6 8 10
Km
Cedar River
Wapsipinicon River
STANWOOD CHANNEL
CLEONA CHANNEL

previously defined Iowan erosion surface. This includes the area within the northern tier of townships in Cedar County, the adjacent township in Clinton County, and the area delineated by the Tipton lobe of the Iowan erosion surface (Figure 2).

The thickest deposits of Quaternary sediments are within the bedrock valleys designated as the Stanwood and Cleona channels (Figure 8). The bedrock valley cut by the Cleona channel is easily recognized on the modern landscape (Figure 8). A sharp change in elevation and ascending slopes occur on the transitional landscape along the north, northwest, and south, southeast boundaries of the Cleona landscape. For example, in sec. 24, T.79, R.1W. the elevation increases from 700 to 760 feet across a ground surface of approximately 3000 feet. The modern landforms which delineate the relict valley walls show that the landscape of the Cleona channel is 1 mile wide in southeast Cedar County. Similar and greater distances are the rule along the entire southeasterly portion of the study area (Figure 8). On the other hand, there is no evidence on the modern landscape indicating existence of the Stanwood channel and it cannot be identified from the topography of the modern ground surface. The Stanwood channel coincides with the modern valley of Spring Creek for a distance of less than 3 miles (Hansen, 1972). Otherwise, deposits covering the buried channel often form the stable upland positions of the modern landscape.

Stratigraphy

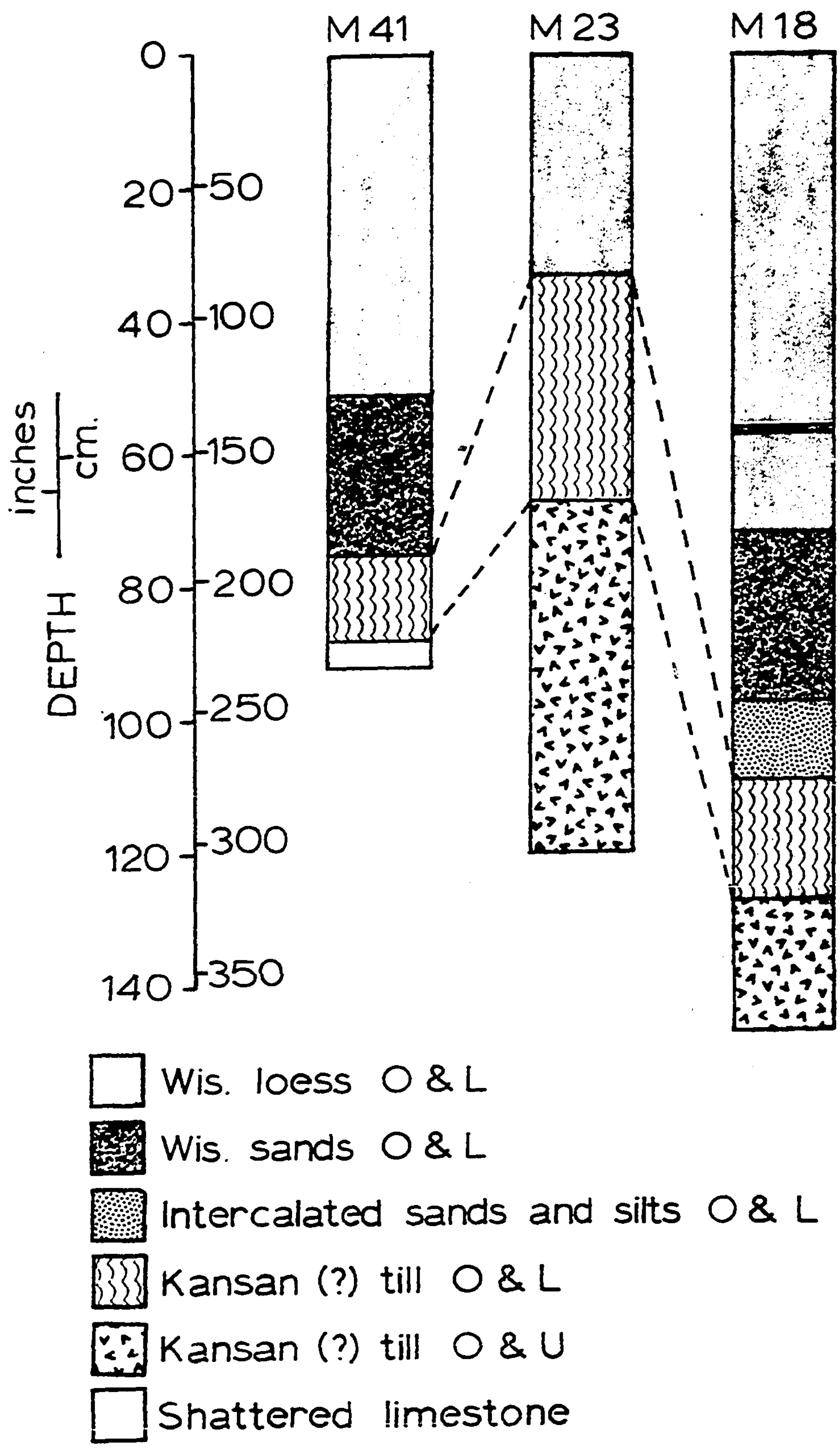
Stratigraphy is the science that is concerned with the study of the formation, composition, sequence, and correlation of materials as parts of the earth's crust (American Geological Institute, 1962). Subsurface studies can be made by observing natural or artificial cuts in the earth. If cuts are not available then the subsurface can be observed by drilling or coring and extracting undisturbed, continuous cores. Observation of the subsurface is then limited to the sites of the coreholes. Extrapolation must be made from site to site. However, this method allows for the construction of a three-dimensional view of the subsurface. In Iowa the Quarternary studies conducted during the past 25 years have been built on three-dimensional interpretations (Ruhe, 1969a).

Reconnaissance traverse

Coreholes 16-M41, M23, and M18 are located north of the southern extent of the Iowan boundary along the interstream divide (Figure 2). Profile M41 consists of thin loess, above sands, which in turn occur above till over bedrock. The latter contact is at 7.1 feet. Profile M23 consists of thin loess above leached till, and profile M18 consists of loess above intercalated sands, which are located above sands that overlie leached till. Stratigraphic columns for these three profiles are shown in Figure 9.

The loess thickness for these three cores are: 16-M41,

Figure 9. Stratigraphic materials sequence and weathering zones in coreholes 16-M18, 16-M23, and 16-M41, located in northern Cedar County



M 41
M 23
M 18
0
20
40
60
80
100
120
140
50
100
150
200
250
300
350
DEPTH
inches
cm.
Wis. loess O & L
Wis. sands O & L
Intercalated sands and silts O & L
Kansan (?) till O & L
Kansan (?) till O & U
Shattered limestone

4.2 feet; 16-M23, 2.8 feet; and 16-M18, 6.0 feet. The thickness of the sand zones are 2.0 and 3.1 feet in M41 and M18, respectively. All three cores reveal that no paleosol is present on the till surface.

Particle-size distribution of the sand, silt, and clay fractions for cores 16-M18 and M41 are plotted in Figure 10. In core M18 an upper sand lens occurs at 56 to 57 inches. The sand component accounts for 75.9% of the total sample. The medium sand accounts for 31.6% and the fine and very fine sand accounts for 40.5% of the total sample. The percentage of silt increases from 11.7% in the 56- to 57-inch zone to 71.3, 67.9, and 56.9% in the succeeding three horizons. From a depth of 72 to 109 inches the sand fraction is the dominant component of the particle-size distribution (Figure 10). In these sampling horizons the sand distribution is unimodal and the largest component is in the medium sand fraction. No particles > 2-mm were found in the samples. The clay maximum in the underlying till is 25% at 121 inches.

In core 16-M41 the sand unit was contacted at a depth of 51 inches. The maximum percentage of sand, 62.5%, occurred at 60 inches. Field and laboratory evidence indicates that some lag particles, > 2-mm, are present in the lower part of the sand unit. The percentage of these coarser particles by weight were determined by sampling horizons: (1) 57-63, 3.6%; (2) 63-69, 2.5%; (3) 69-75, 2.0%; and (4) 75-81, 2.9%. The portion of the underlying till sampled ranged from 20.0 to

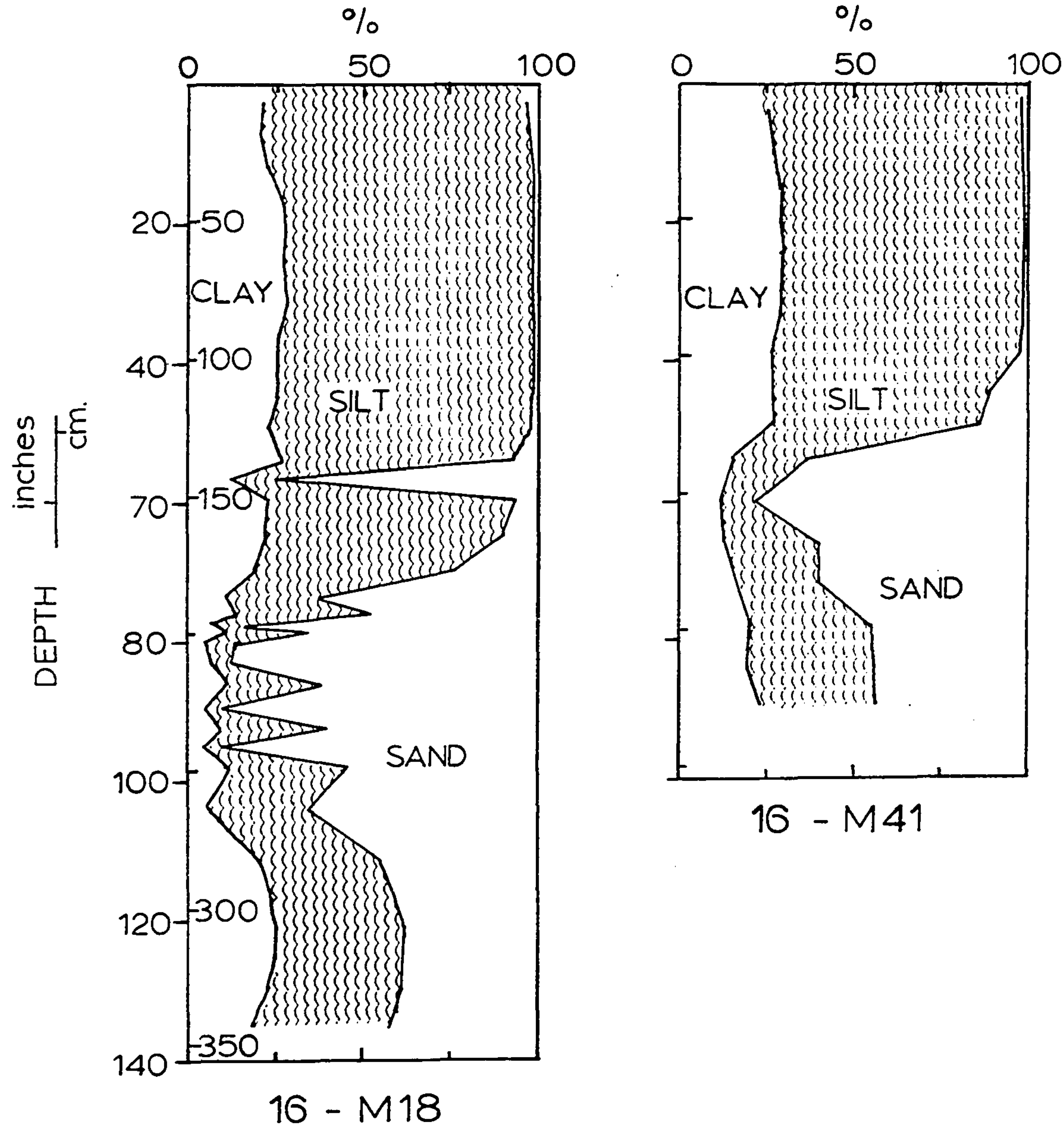


Figure 10. Distribution of sand, silt, and clay fractions versus depth in coreholes 16-M18 and 16-M41

23.0% in clay-sized particles. The matrix color of the till is brown (10YR 4/3).

South of the Iowan border (Figure 2) two cores were collected in sections 11 and 12, T.81N., R.2W. Core 16-M19 is located in the NW$\frac{1}{4}$, sec. 12 at a surface elevation of 894 feet. This site is located on the stable summit of a ridge aligned along a east-west axis which is normal to the interstream divide. This core contains 29.7 feet of loess above a Yarmouth-Sangamon paleosol (Table 5). To the south and southwest the flank of this ridge grades downward along the interstream divide to a surface elevation of approximately 855 feet (Figure 11). At a distance of 3800 feet southwest of corehole M19, core 16-M12 was collected. Core M12 is located on a well-drained upland site on the primary divide. The stratigraphic units of this core are 12.8 feet of loess above 5.0 feet of sands overlying oxidized and leached till (Table 5).

This transect provides for the introduction of a truncated till surface overlain by a thick increment of sands and loess. More significant is the fact the truncated till surface at core M12 is on a stable upland position along the topographic divide of the Wapsipinicon and Cedar Rivers, and is located at least 1.5 miles south of the previously recognized Iowan border (Figure 2).

Nearly 3 miles southeast of corehole 16-M19, corehold 16-M11 was collected. Corehole M11 is located on the stable

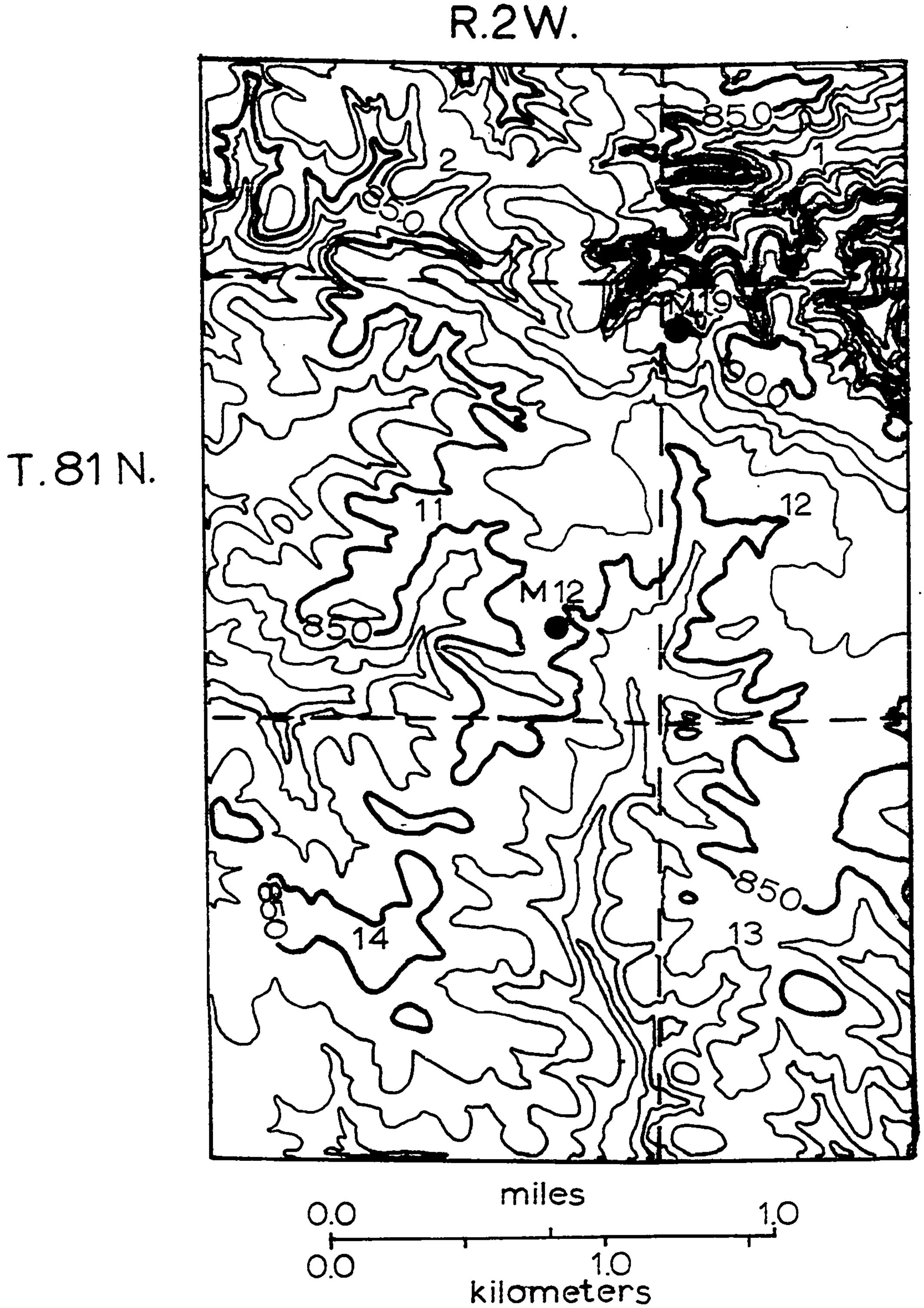
Table 5. Stratigraphic materials and weathering zones for coreholes 16-M12 and M19, sections 11 and 12, T.81N., R.2W.

16-M19		16-M12	
Depth (ft)	Materials and weathering zones	Depth (ft)	Materials and weathering zones
0.0-8.1	Loess, O & L	0.0-8.5	Loess, O & L
8.1-11.0	Loess, O & U	8.5-10.7	Loess, O & U
11.0-13.7	Loess, D & U	10.7-12.8	Loess, D & U
13.7-18.8	Loess, O & U	12.8-15.3	Sands, O & U
18.8-20.1	Loess, D & U	15.3-17.8	Sands, O & U
20.1-26.8	Loess, U & U	17.8-20.0	Till, O & L
26.8-27.3	Apb, BWP	20.0-21.0+	Till, O & U
27.3-29.7	Cb, BWP		
29.7-30.0+	All, YSP		

upland of the primary divide near the center of sec. 25, T.81N., R.2W. (Figure 2). This profile consists of 16.5 feet loess above 8.3 feet of sands which are superjacent to a truncated till surface. The till is oxidized and leached to a depth of at least 3.5 feet.

In T.80N., R.1W. (Figures 4 and 5) the primary divide is characterized by a broad plain. This plain has a micro-relief of swell-swale topography. The common slope feature is a convex knob, a long, linear backslope of 1000 feet or more in length, with a slope range of 1 to 3%, and a concave depression

Figure 11. Topographic map showing the location of coreholes 16-M12 and 16-M19. Contour interval is 10-foot

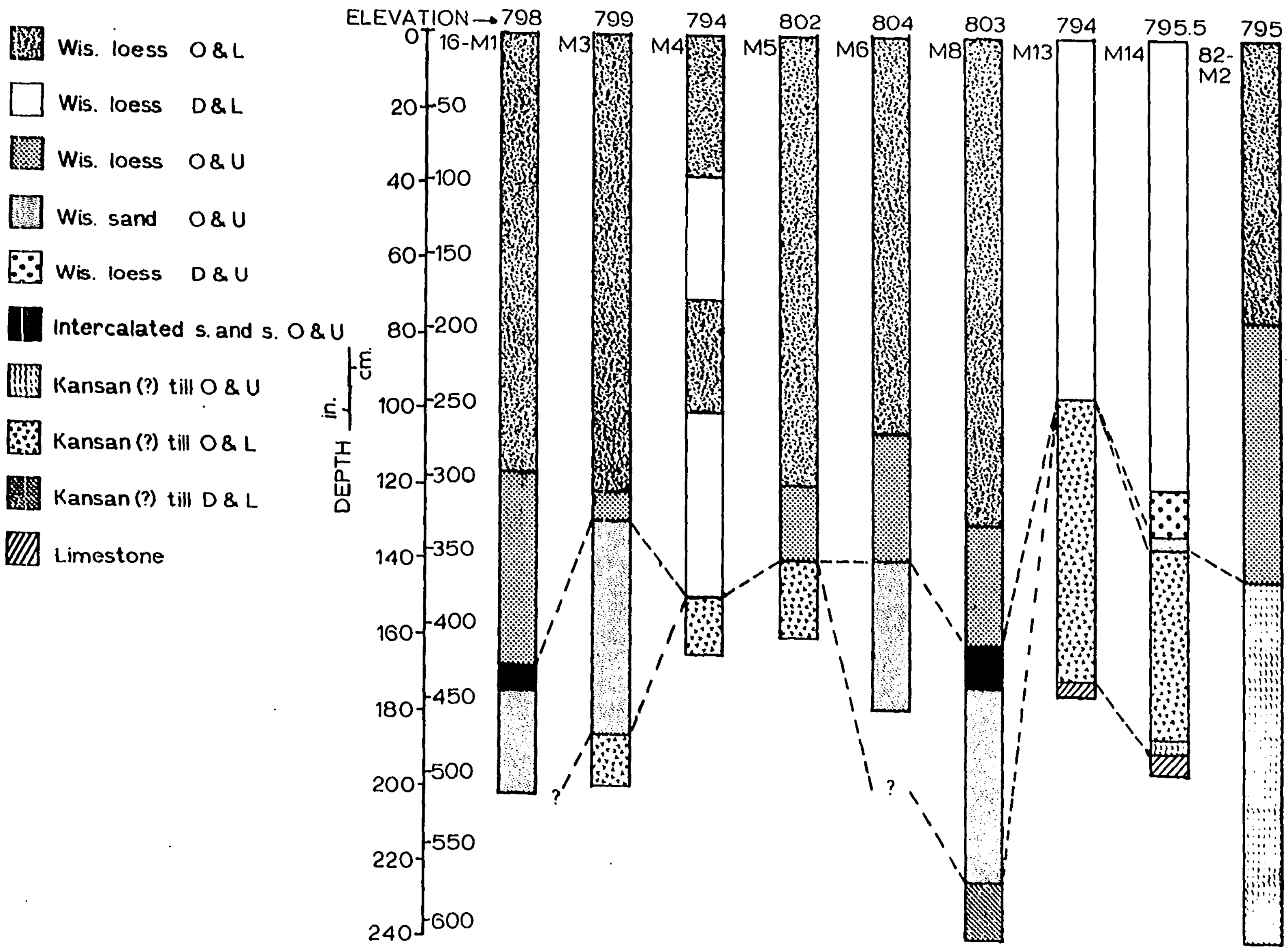

R.2W.
T.81N.
850
2
850
1
M19
900
11
12
M12
850
850
13
14
miles
0.0
1.0
0.0
1.0
kilometers

at the base of the slope. Some of these depressions represent the heads of first order drainageways, but closed depressions are the rule rather than the exception. Stream dissection is at a minimum. The majority of this landscape occurs within sections 13, 14, 21, 22, 23, 24, 25, 26, 27, 28, 32, 33, 34, and 35, T.80N., R.1W.; sections 2, 3, 4, 5, 6, 10, and 11, T.79N., R.1W.; and sections 19, 20, 27, 28, 29, 30, and 31, T.80N., R.1E. Norton (1899, p. 410) made note of this landscape in the New Liberty, Scott County, area. He provided additional description of the landscape in the Geological Survey Report of Cedar County (Norton, 1901, p. 352). In modern times this area has been termed the "Sunbury Flat" (Arnold, 1963, p. 124). This surface will be referred to as the Sunbury Flat area in the remainder of this dissertation.

Coreholes collected on the Sunbury landscape include 16-M1, M3, M4, M5, M6, M8, M13, and M14 in Cedar County, and 82-M2 in Scott County (Figures 2, 4, and 5). Coreholes M1, M3, M5, M6, and M8 are located at stable convex swells representing well-drained positions on the landscape. Coreholes M4, M13, M14, and 82-M2 are located at footslope, toeslope, or swale positions. Figure 12 shows the stratigraphic distribution of materials and weathering zones for these coreholes.

The coreholes located on the well-drained swells contain an increment of sand intercalated between the base of loess and the till surface. Corehole M5 is an exception. All the coreholes located on a footslope or toeslope positions on this

Figure 12. Stratigraphic materials sequence, weathering zones, and ground surface elevation for coreholes located in the Sunbury Flat area

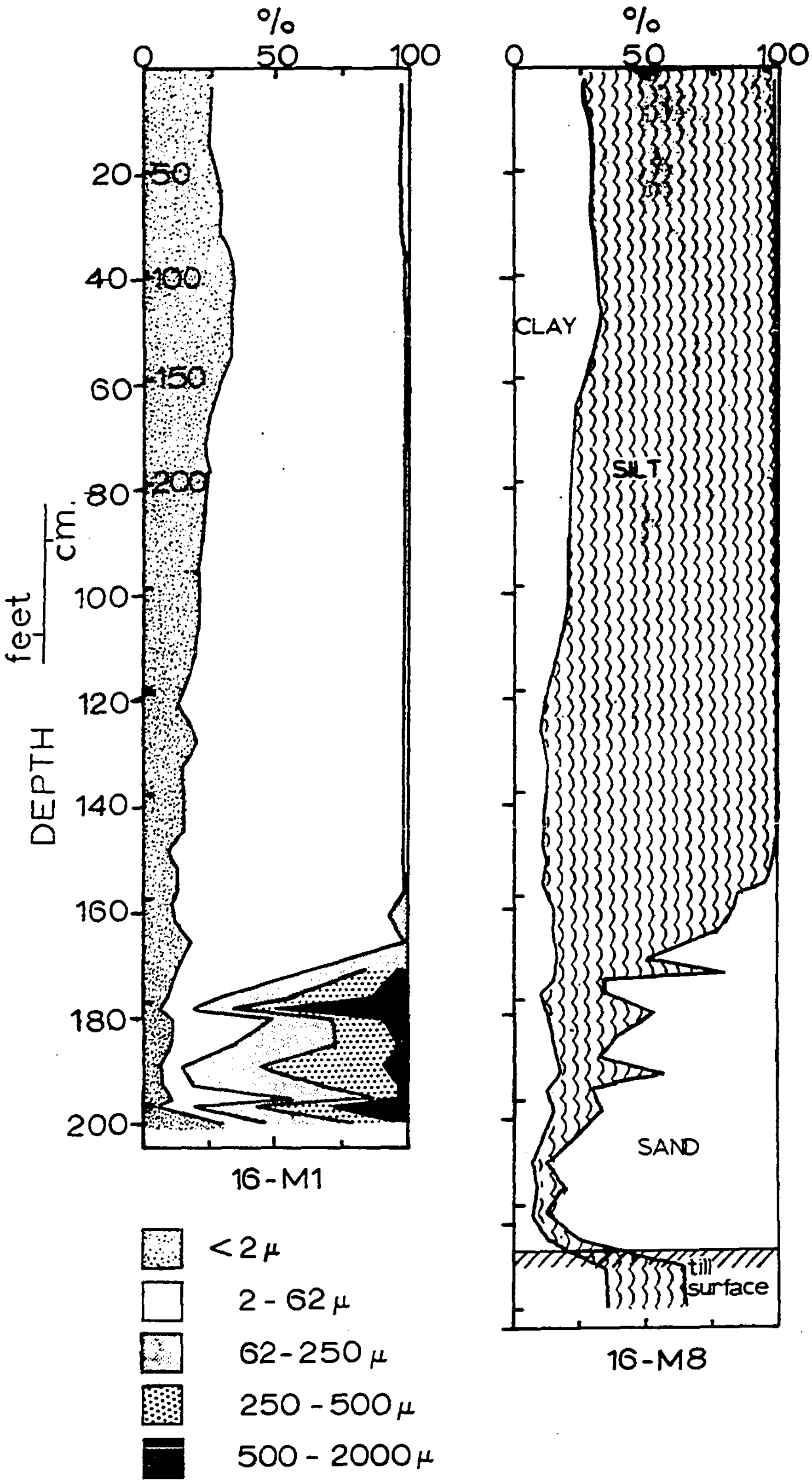

Wis. loess O & L
Wis. loess D & L
Wis. loess O & U
Wis. sand O & U
Wis. loess D & U
Intercalated s. and s. O & U
Kansan (?) till O & U
Kansan (?) till O & L
Kansan (?) till D & L
Limestone
ELEVATION → 798
799
794
802
804
803
794
795.5
795
16-M1
M3
M4
M5
M6
M8
M13
M14
82-M2
DEPTH in. cm.
0
20
40
60
80
100
120
140
160
180
200
220
240
50
100
150
200
250
300
350
400
450
500
550
600
?
?

surface lack an increment of sand in their stratigraphic column. A thin sand lens occurs above the till contact in corehole M14. However, this corehole is located 40 feet upslope from core 16-M13. The latter corehole is located in the center of a closed depression.

The sand zone contact in core 16-M1 is at 168 inches. In the subjacent 34 inches the sand fraction ranges from 36.3 to 84.9% of the sample horizon (Figure 13). The depositional history of this zone is complex. For example, in sample horizon 175-178 inches 30.2% of the sample is in the fine and very fine sand fraction, and 11.8% is in coarse and very coarse sand fraction. In the next lower sample horizon, 178-179 inches, the fine and very fine sand fraction contains 15.2% of the sample, the medium - 6.9%, and the coarse and very coarse sand fraction is 48.2% of the sample. The particle-size distribution of sample horizons 182-188, 188-191, and 191-195 inches are shown in Figure 14.

The particle-size distribution of the sand zone in core 16-M3 differs from that of core 16-M1. The sand zone was penetrated at 122 inches. The zone contains a silt band at 140 to 146 inches. However, the particle-size distribution of the sand-size components are more or less uniform (Figure 15). With the exception of sample horizons 126-130 and 141-146 inches the greatest percentage of the sand within the 62 to 2000 μ component occurs in the medium size fraction. Sample horizons 126-130 and 141-146 inches have a higher percentage

Figure 13. Distribution of clay (< 2 μ), silt (2-62 μ), very fine and fine sand (62-250 μ), medium sand (250-500 μ), and coarse and very coarse sand (500-2000 μ) fractions versus depth for corehole 16-M1 and clay, silt, and sand fractions for corehole 16-M8


%
0
50
100
20
40
60
80
100
120
140
160
180
200
50
100
150
200
DEPTH feet/cm.
16-M1
<2μ
2-62μ
62-250μ
250-500μ
500-2000μ
CLAY
SILT
SAND
till surface
16-M8

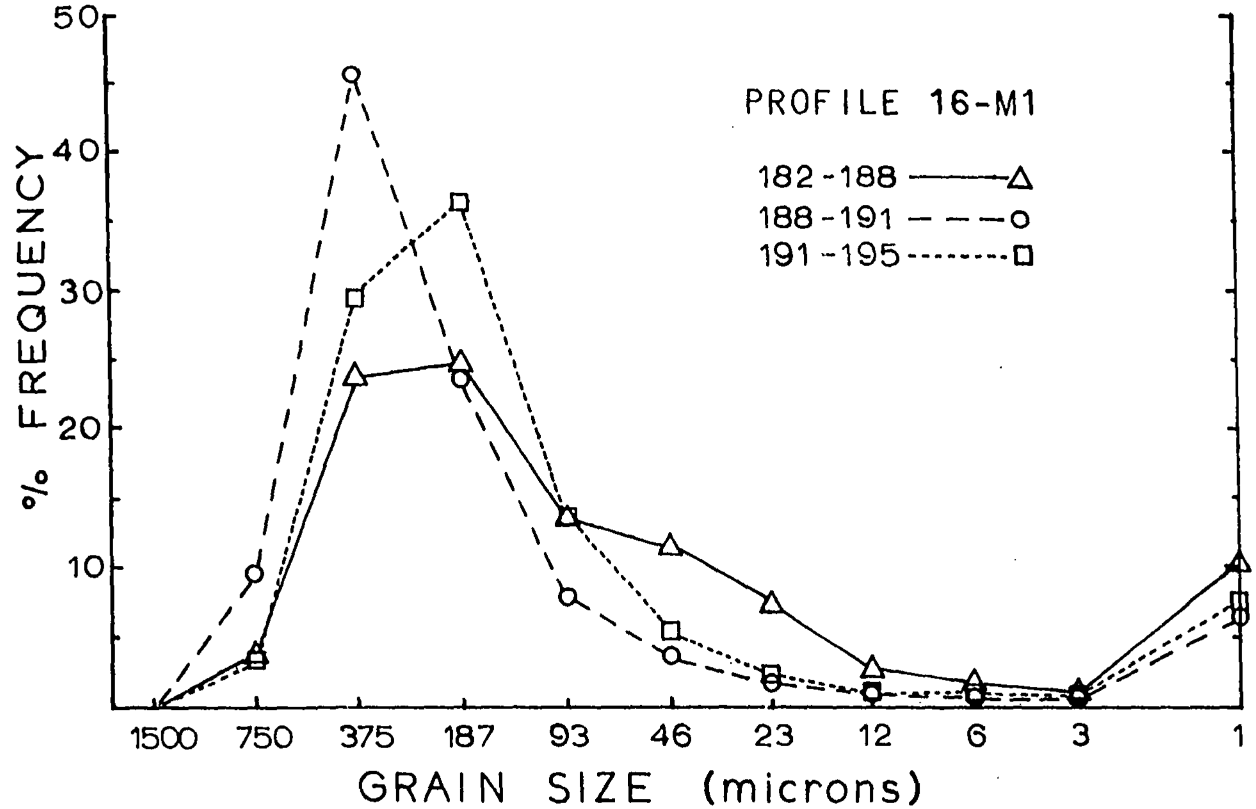


Figure 14. Frequency percentage plot of particle-size distribution for three sample horizons from a sand zone in corehole 16-M1

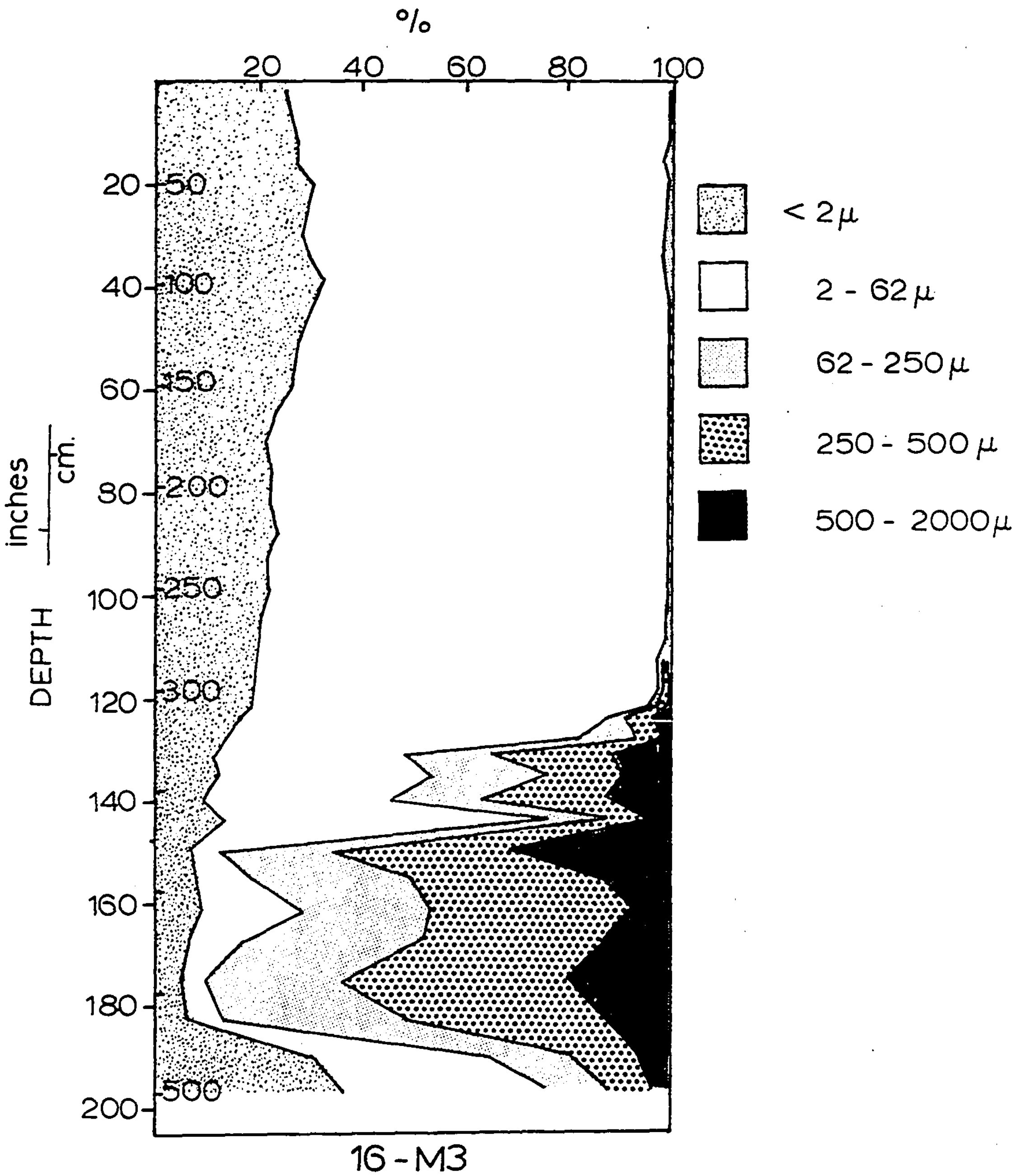


Figure 15. Distribution of clay (< 2 μ), silt (2-62 μ), very fine and fine sand (62-250 μ), medium sand (250-500 μ), and coarse and very coarse sand (500-2000 μ) fractions versus depth for corehole 16-M3

of sand in the fine and very fine sand fraction. These two horizons are dominated by silt-size particles.

The particle-size distribution for cores 16-M4, M5, and M6 is given in Table 6. No sand zone occurs in cores M4 and M5. The underlying till in core M4 has a maximum of 35.0% < 2 μ clay. The till in core M6 has a maximum of 23.3% < 2 μ clay. In core M6 the sand zone contact is at 140 inches. The particle-size distribution in the sand zone has a maximum of 80.0% sand in the 159-166 inch sample horizon.

The particle-size distribution of core 16-M8 is given in Figure 13. The sand zone contact is buried beneath the loess at 156 inches. Intercalcated bands of silt within the sand zone are at 172, 179, and 191 inches. The maximum percentage of sand-size particles occur in the lower 24 inches of this 71-inch zone. The < 2 μ clay in the underlying till is 34.2 and 35.7% for two sample horizons.

The five cores located at well-drained convex swells: 16-M1, M3, M5, M6, and M8, contain oxidized loess of 168, 128, 139, 139, and 162 inches in thickness, respectively (Figure 12). Sand zones in these cores range from 0.0 to 56 inches in thickness. No paleosols occur on the till surface.

Cores located at footslope, toeslope, and swale positions on the landscape, M4, M13, M14, and 82-M2, contain loess of 150, 96, 132, and 144 inches in thickness, respectively (Figure 12). A sand zone 4 inches thick was identified in core M14.

Table 6. Particle-size analysis and weathering zone stratigraphy for cores 16-M4, 16-M5, and 16-M6

	Percentage		
Depth (in.)	Sand (> 62 µ)	Silt (62-2 µ)	Clay (< 2 µ)
	Core 16-M4		
Leached loess			
0-7	0.6	72.0	27.4
7-13	0.6	75.2	24.2
13-17	1.6	82.8	15.6
17-23	1.5	74.1	24.4
23-30	2.1	63.7	34.2
30-34	2.1	62.8	35.1
34-38	2.5	63.7	33.8
38-45	1.6	65.7	32.7
45-51	1.8	70.1	28.1
51-56	1.4	72.4	26.2
56-61	1.7	74.1	24.2
61-66	2.6	72.3	25.1
66-71	1.2	74.4	24.4
71-77	1.1	74.3	24.6
77-83	1.2	74.5	24.3
83-89	1.0	74.8	24.2
89-95	1.4	77.5	21.1
95-101	2.9	74.9	22.2
101-106	2.1	74.8	23.1
106-112	1.4	76.6	22.0
112-118	0.7	78.6	20.7
118-123	0.4	80.0	19.6
123-128	0.3	80.6	19.1
128-135	0.5	80.6	18.9
135-140	0.3	81.8	17.9
140-145	0.6	80.8	18.6
Kansan till			
145-150	29.9	35.1	35.0
150-155	31.7	36.8	31.5
155-165	30.8	38.8	30.4
	Core 16-M5		
Leached loess			
0-6	1.7	73.6	24.7
6-10	1.6	73.2	25.2

Table 6. (Continued)

Depth (in.)	Percentage Sand (> 62 μ)	Silt (62-2 μ)	Clay (< 2 μ)
Core 16-M5 (continued)			
Leached loess (continued)			
10-16	1.4	71.3	27.3
16-23	1.2	69.4	29.4
23-27	1.2	68.9	29.9
27-32	1.4	69.9	28.7
32-36	1.6	68.9	29.5
36-40	2.4	69.4	28.2
40-49	1.7	71.3	27.0
49-53	1.0	73.7	25.3
53-58	0.8	74.0	25.2
58-63	0.7	74.4	24.9
63-69	0.8	75.1	24.1
69-75	0.7	73.0	26.3
73-81	1.7	72.9	25.4
81-87	3.5	71.3	25.2
87-93	0.5	75.2	24.3
93-99	0.7	79.6	19.7
99-105	0.5	79.0	20.5
105-111	0.6	79.5	19.9
111-117	0.6	79.8	19.6
Unleached loess			
117-120	0.5	81.3	18.2
120-126	0.7	87.1	12.2
126-132	0.6	85.9	13.5
132-140	2.9	84.1	13.0
Kansan till			
140-146	48.4	28.3	23.3
146-152	52.7	25.3	22.0
152-160	47.3	29.9	22.8
Core 16-M6			
Leached loess			
0-7	1.4	71.4	27.2
7-11	1.5	70.3	28.2
11-15	1.4	69.5	29.1

Table 6. (Continued)

Depth (in.)	Percentage Sand (> 62 μ)	Silt (62-2 μ)	Clay (< 2 μ)
Core 16-M6 (continued)			
<u>Leached loess</u> (continued)			
15-21	1.3	69.2	29.5
21-25	1.2	69.3	29.5
25-30	1.2	68.6	30.2
30-35	1.4	68.5	30.1
35-42	2.2	67.5	30.3
42-47	1.6	66.9	31.5
47-52	1.3	70.2	28.5
52-58	0.6	72.9	26.5
58-64	0.8	74.5	24.7
64-70	0.9	73.1	26.0
70-76	0.7	74.6	24.7
76-82	0.6	75.4	24.0
82-88	0.6	77.0	22.4
88-94	0.7	76.9	22.4
94-100	0.9	79.6	19.5
100-106	0.6	80.0	19.4
<u>Unleached loess</u>			
106-113	0.8	84.6	12.8
113-119	0.8	87.7	11.5
119-125	0.6	87.4	12.0
125-131	1.3	86.1	12.6
131-136	1.7	85.6	12.7
136-140	5.0	80.7	14.3
<u>Unleached sands</u>			
140-148	26.3	60.4	13.3
148-155	47.9	38.5	13.6
155-159	68.9	18.7	11.4
159-166	80.0	10.2	9.8
166-172	71.8	17.4	10.8
172-179	64.4	24.1	11.5

The matrix colors of the till units were identified in three cores. In core 16-M4 the matrix colors were light olive brown (2.5Y 5/4) grading with depth to olive gray (5Y 5/3) and light olive brown (2.5Y 5/4). In core 16-M5 the matrix colors were yellowish brown (10YR 5/6) and in core 16-M8 the colors were dark gray to olive gray (5Y 4/1 to 4/2).

Coreholes 16-M13 and M14 are located in the NE corner of sec. 26, T.80N., R.1W. (Figure 5). The contact with the underlying bedrock was made at 170 and 184 inches, respectively. Unfortunately, these cores were collected subsequent to cores M5 and M6, well drained sites located on convex swells, which are in the SE¼SE¼ of sec. 23, the adjacent section. Thus no effort was made to penetrate the till unit to greater depths in the latter two coreholes (Figure 12).

The bedrock in eastern Cedar and western Scott counties has been mapped as the Silurian Gower Formation (Iowa Geological Survey, 1969). This bedrock outcrops at several locations in T.79N., R.1E. and T.80N., R.1E. along the east periphery of the Sunbury Flat (Figure 4). An abandoned rock quarry is located on the east side of the stream in the SW¼ sec. 6, T.79N., R.1E. Kramer (1972, p. 10) noted bedrock outcrops at numerous places along the creek bed of Mud Creek, T.79N., R.1W., and T.79N., R.1E. In addition, an operational rock quarry is located in sec. 28, T.80N., R.1E.

Corehole M10 was made in the SE corner of the NW¼, sec. 2, T.79N., R.1W. (Figure 2). This site is on the interstream divide near the southern edge of the Sunbury Flat. The ground soil is a somewhat poorly drained unit occupying a landscape position upslope of a first-order drainageway head. The material in this core consists of: (1) 12.7 feet of loess above (2) 4.1 feet of sands overlying (3) 2.2 feet of oxidized and leached till. Oxidized and unleached till was contacted at 19.0 feet.

At the southeast end of the reconnaissance traverse two coreholes were made. Core 16-M9 is located in a small depression adjacent to the section line in the SW corner, SE$\frac{1}{4}$ sec. 13, T.79N., R.1W. (Figure 2). This site is on the primary divide at the head of a secondary interfluve which descends onto the Cleona landscape. Core 82-M1 is located on a well-drained convex swell in the SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 30, T.79N., R.1E. (Figure 2). This site is situated on the upland landscape that is set as an island rising above the surrounding Cleona landscape. The latter surface is dissected by Big Elkhorn Creek to the north and Mud Creek to the south. Table 7 summarizes the stratigraphy and weathering zones for coreholes 16-M9 and 82-M1.

Core M9 was the only site in this study where a thick increment of well-sorted sands were found above a basal loess unit other than in those areas abutting and ascending onto a paha. There is no evidence to indicate the presence of a paha or paha-like feature at this site.

The sand zone in core M9 is at a depth of 121 inches

Table 7. Stratigraphic materials and weathering zones for coreholes 16-M9 and 82-M1

16-M9		82-M1	
Depth (ft)	Materials and weathering zones	Depth (ft)	Materials and weathering zones
0.0-8.5	Loess, O & L	0.0-6.5	Loess, O & L
8.5-10.0	Loess, O & U	6.5-10.0	Loess, O & U
10.0-12.8	Sands, O & U	10.0-11.3	Till, O & L
12.8-16.1	Sands, O & L	11.3-17.8+	Till, O & U
16.1-18.8	Loess, D & U		
18.8-23.2+	Till, O & L		

beneath the loess increment (Figure 16). The maximum percentage of sand-sized particles, 89.2% occur at 150 inches. An intercalated band of silts are in the 169 to 176-inch sample horizon. The lower increment of silt-sized particles, loess, occur at 198 inches and come in contact with the truncated till surface at 226 inches.

Four coreholes, 16-M20, M21, M22, and M24 were collected to provide additional input into the areal distribution of stratigraphic units and weathering zones. All four cores are located on stable upland interfluves within the Cedar River watershed (Figure 2). Figure 8 summarizes the stratigraphy and weathering zones found in these cores. Cores 16-M20 and M21 consist of loess and sand units overlying a truncated

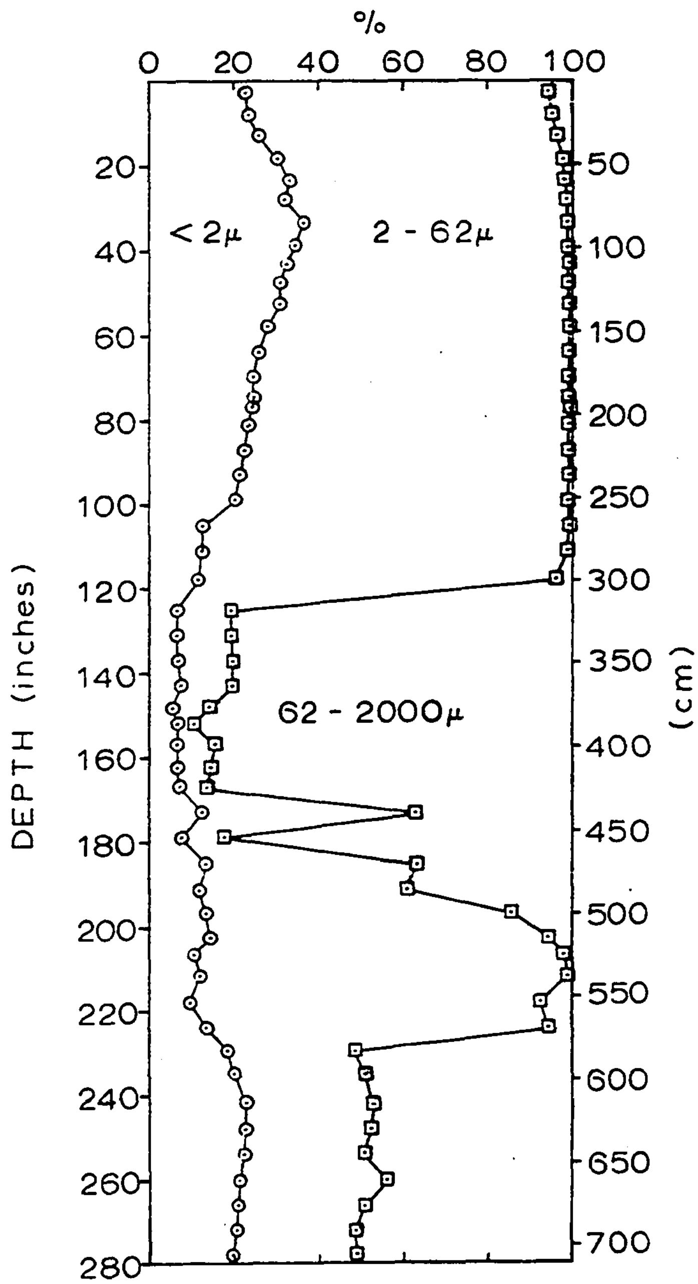


Figure 16. Distribution of clay (< 2 μ), silt (2-62 μ), and sand (62-2000 μ) fractions versus depth for corehole 16-M9

Table 8. Stratigraphic materials and weathering zones for coreholes 16-M20, 16-M21, 16-M22, and 16-M24

Depth (in.)	Materials and weathering zones	Depth (in.)	Materials and weathering zones
	16-M20		16-M21
0.0-12.1	Loess, O & L	0.0-5.1	Loess, O & L
12.1-14.0	Loess, O & U	5.1-13.8	Loess, O & U
14.0-14.5	Sand, O & L	13.8-15.3	Loess, D & U
14.5-17.2	Loess, D & U	15.3-17.9	Till, O & L
17.2-23.6	Sand, O & U	17.9-20.0	Till, O & U
	16-M22		16-M24
0.0-5.7	Loess, O & L	0.0-7.3	Loess, O & L
5.7-5.9	Sand, O & L	7.3-12.2	Loess, O & U
5.9-6.6	Loess, O & L	12.2-12.7	Loess, D & U
6.6-9.4	Sand, O & L	12.7-14.1	Loess, O & U
9.4-11.7	Intercalated sands in loess	14.1-23.7	Loess, U & U
		23.7-24.0	Apb, BWP
11.7-13.5	Loess, O & L	24.0-24.8	Cb, BWP
13.5-19.7	Loess, O & U	24.8-27.7	YSP
19.7-25.8	Loess, D & U		
25.8-26.5	Apb, BWP		
26.5-28.0	Cb, BWP		
28.0-29.2+	YSP		

till surface. Cores M22 and M24 consist of up to 25.0 feet of loess above the BWP which overlies the YSP.

Bennett transect

This transect provides the detailed stratigraphy of materials in a paha and on the abutting Iowan erosion surface. The paha is located in sections 12 and 13 (Figures 4 and 5) and is part of an inlier which flanks the northwest shoulder of the Cedar-Wapsipinicon River divide. The inlier sets along a northwest-southeast axis from its intersection at the Cedar-Scott counties line until it merges into the Iowan surface in sections 31 and 32, T.81N., R.1W. This paha will be known as the Bennett paha. The abutting Iowan erosion surface is the northern limit of the Sunbury Flat area which was described in a previous section.

In the Bennett transect coreholes 16-M15, M26, M27, and M29 consist of thick loess above the BWP on the YSP (Figure 17). Core M15 is on the summit of the paha, and cores M26, M27, and M29 are located on the shoulder and backslope along the south-facing flank of the paha. Core M28 consists of thick loess with intercalated sands above the BWP. Coreholes M30, M31, M25, M32, and M7A contain a thick loess unit over a truncated till surface. An increment of sands is between the base of the loess and the truncated till surface in cores M7A, M30, and M32.

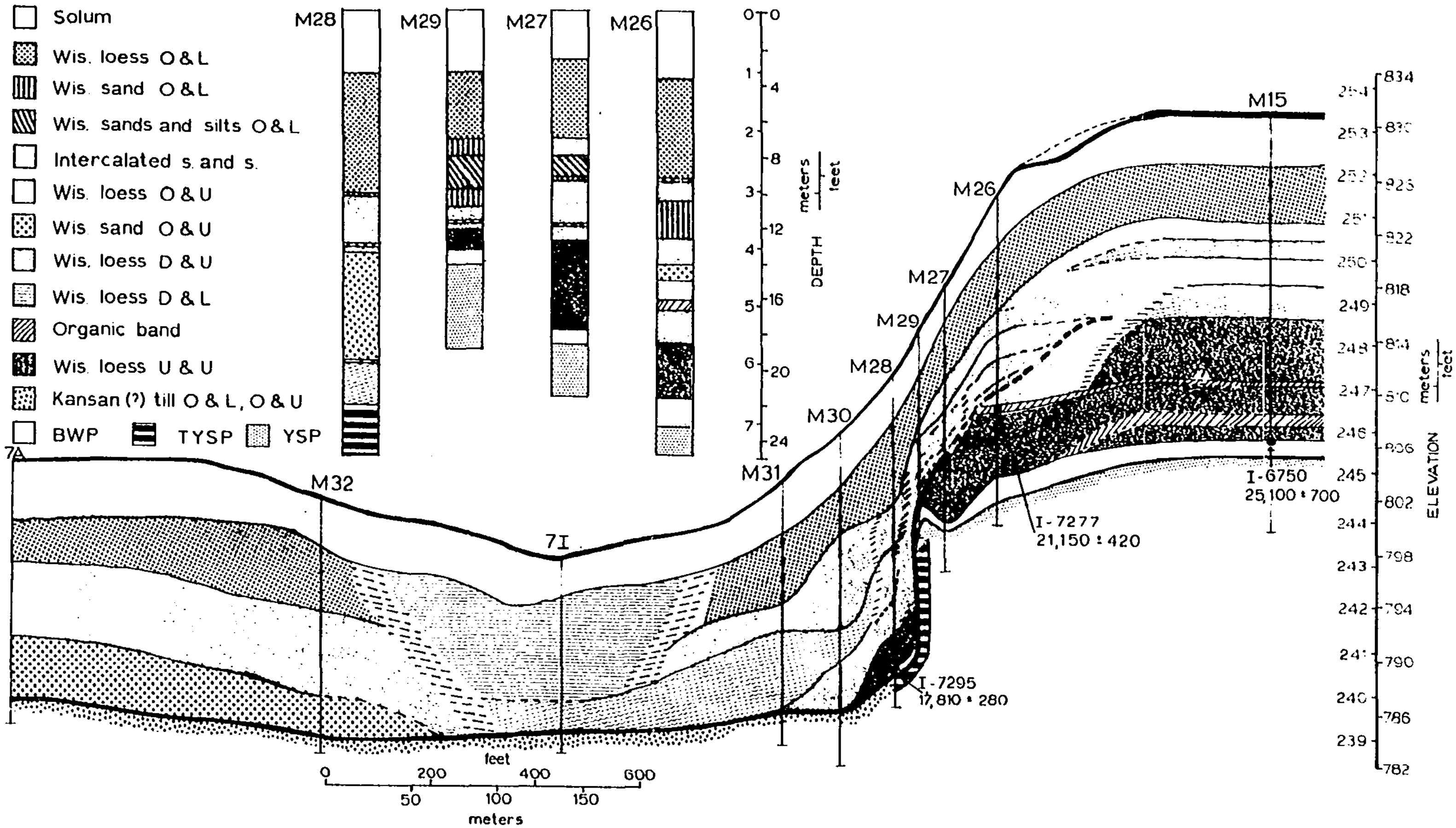


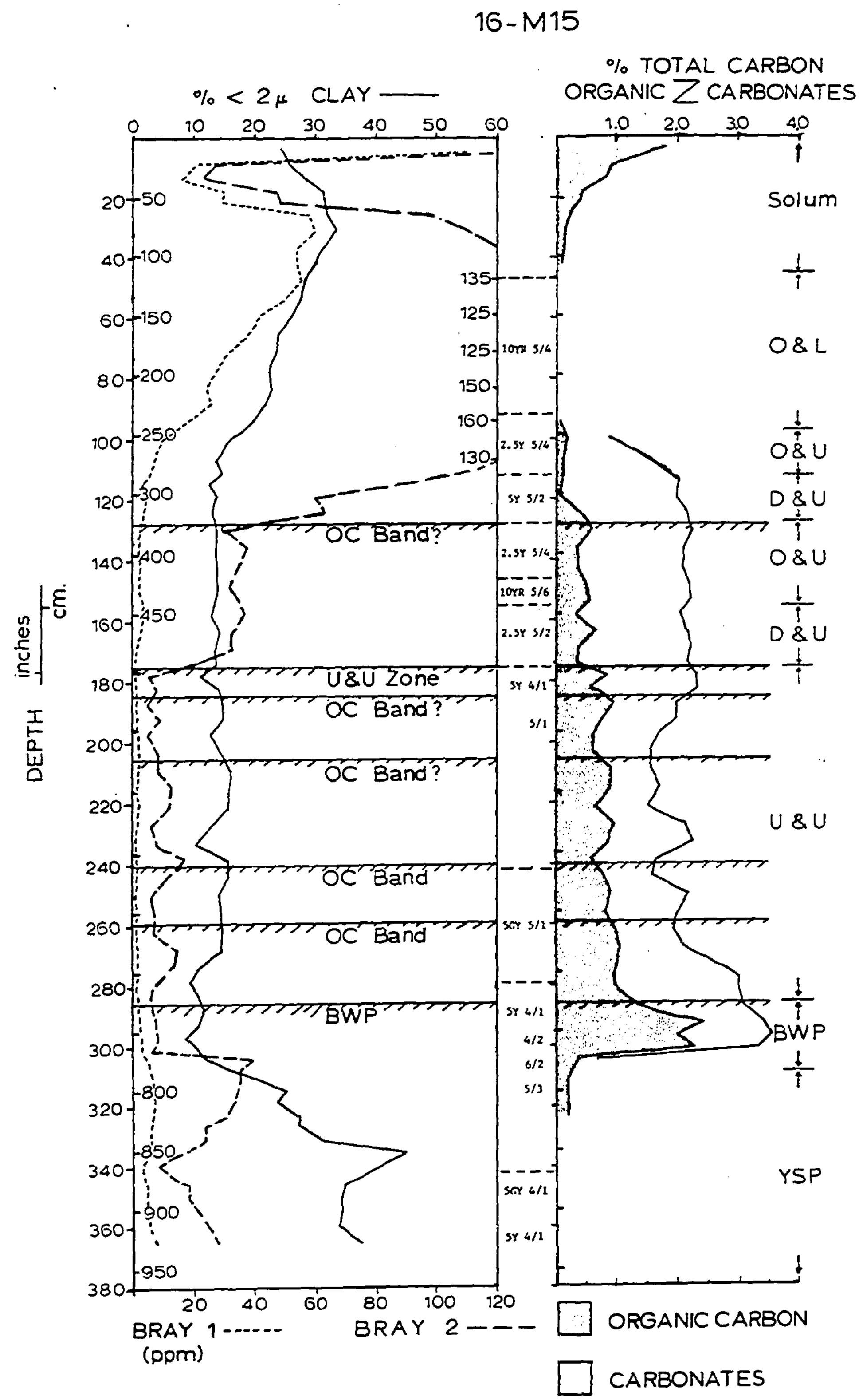
Figure 17. Stratigraphic cross-section of the Bennett paha and Bennett transect

Core 16-M15 The loess thickness on the summit of the Bennett paha is 25.8 feet. Core 16-M15 consists of the full increment of Wisconsinan loess deposits (Figure 18). The upper oxidized loess is 9.3 feet thick. Subjacent to the oxidized loess is a deoxidized and unleached zone. This zone is at 9.3 to 10.6 feet and overlies an oxidized and unleached zone that extends from 10.6 to 12.9 feet. A second deoxidized and unleached loess zone occurs at 12.9 feet and extends to 15.0 feet. Unoxidized loess, including the BWP account for the remaining 10.8 feet of loess. The underlying YSP was penetrated to a depth of 4.9 feet.

There is no evidence of a sand zone or intercalated sands extending onto and across the summit of the paha. Below the base of the solum in core M15 (Figure 18; Appendix B) the greatest percentage of particle sizes > 62 μ, 2.7%, are in the 176 to 180-inch sample horizon. This sample is located at the base of the deoxidized loess. The increase in sand-sized particles in this sample horizon is accounted for by the increased amount of iron oxide and manganese oxide concretions concentrated in this zone, and included in the sand fraction.

The silt component, 2 to 62 μ, indicates a unimodal distribution of particle size within that size range. Throughout the loess column the greatest percentage of silt-sized particles are in the 16 to 31 μ fraction (see data for core 16-M15 in Appendix B). Below a depth of 60 inches the percentage of 16

Figure 18. Distribution of clay, AP1 (Bray 1), AP2 (Bray 2), OC, and carbonates versus depth for core 16-M15. Munsell colors are given for the dominant matrix colors in the respective weathering zone


16-M15
% < 2μ CLAY
% TOTAL CARBON
ORGANIC CARBONATES
DEPTH inches cm.
BRAY 1 (ppm)
BRAY 2
OC Band?
U&U Zone
OC Band
BWP
Solum
O & L
O & U
D & U
U & U
YSP
ORGANIC CARBON
CARBONATES

to 31 μ particles range from 30.5 to 40.9%.

The clay component, < 2 μ, has a more or less constant distribution in the loess column. In the leached zone the maximum clay content occurs from 30 to 34 inches, in the B2 horizon of the ground soil. At the base of the leached zone the clay increases to 19.9%. In the unleached zone the maximum clay content is 15.2% (Figure 18). In the unoxidized and unleached zone (Figure 18) the unsystematic increases in clay may be associated with organic carbon bands which represent periods of cessation of the loess deposition. However, the clay increases at those locations are not necessarily indicative of pedogenesis. In western Iowa increases of up to 6% clay associated with organic bands were shown to be sedimentologic phenomena (Ruhe et al., 1971). The percentage of clay reaches a minimum at 278 inches (Figure 18) just above the BWP. An increase of 3.1% clay occurs within the BWP unit and at the loess-YSP contact decreases to 8.5%, the minimum percentage within the loess column. The increase of clay in the underlying material is due to the YSP on the till. This unit will be discussed in a subsequent section.

The distribution of the percentage of total carbon in core 16-M15 is presented in Figure 18. For the purpose of showing depth distribution, carbonates are plotted in terms of total carbon values. The percentage of organic carbon is 1.76% at the surface of the ground soil. The organic carbon decreases to less than 0.12% at 39 inches. Total and organic carbon values of less than 0.12% are approaching the range of error for the analytical procedure (Tabatabai and Bremner, 1970). The unleached zone begins at 97 inches (Figure 18). Organic carbon values obtained for the 91 to 121-inch zone are also approaching the error range of analytical procedure. However, these values are in reasonable agreement with OC values reported for the loess matrix in western Iowa (Handy and Davidson, 1956; Daniels and Handy, 1959; Daniels, Handy, and Simonson, 1960; Ruhe et al., 1971). At 124 inches the percentage of OC is 0.44. The values did not decrease below 0.35% throughout the remaining loess increment. The OC reaches a maximum of 2.42% in the BWP. A radiocarbon date was obtained from the 290 to 295-inch sample horizon. This is the Alb horizon of the BWP. Organic carbon and charcoal flecks in this horizon were found to be 25,100 ± 700 years (I-6750[1]) before present (Figure 17).

The greatest quantity of carbonates are in the oxidized and unleached zones and deoxidized and unleached zones. These zones, 91 to 180 inches (Figure 18) have an average value of 1.64% carbonate in terms of total carbon or 13.69% in terms of calcium carbonate equivalent. In these weathering zones the OC averages 0.34%. In the subjacent unoxidized zone of the loess column, 180 to 306 inches, the average value of the

[1]Isotopes, Inc. The sample identification number assigned by the laboratory determining the radiocarbon date.

carbonate is 1.23% in terms of total carbon or 10.23% calcium carbonate equivalent. In this weathering zone the OC averages 1.04%. In Figure 18 five organic carbon bands have been identified. This identification as shown in Figure 18 is based mainly on laboratory data. The model for the basic depositional unit is the same that has been proposed by other investigators (Handy and Davidson, 1956; Hallberg, Hoyer, and Miller, 1974). In this model incipient weathering zones can be identified in sample horizons that have an increase in OC and a decrease in carbonates. Usually there is a decrease in carbonates in comparison to overlying sample horizons. A change in the clay content is not necessarily a diagnostic criterion for the depositional model. In core 16-M15 the basic depositional model can be identified at four locations in the unoxidized zone (Figure 18): at 185, 206, 245, and 259 inches. The identification of an OC band at 128 inches in the deoxidized zone is questionable, as this band is associated with an increase in carbonates.

The surface of the YSP occurs at an elevation of 805.1 feet (Figure 17). A total of 56 inches of sample was collected from this paleosol. The sand content ranges from < 1% at 309 inches to 4.1% at 360 to 367 inches (Figure 18). The greatest percentage of silt-sized particles are in the 8 to 16 µ and 16 to 31 µ fractions. The clay fraction is 20.9% at the paleosurface, 309 inches, and increases to 44.5% at 335 inches, then decreases to 34.0% in the next 15 inches. The clay fraction begins to increase again at the base of the sample (Figure 18). Unfortunately, with the available field equipment deeper cores could not be obtained.

The distribution of the clay and sand components of the YSP in core M15 is plotted in Figure 19. A comparison of these YSP textural components of core M15 are made with a YSP from Tama County, core G-402 (Fenton, 1966) in Figure 19. The low sand content of core M15 in the upper 48 inches, as compared to the low clay content of the upper 23 inches, indicates that this paleosol may have formed from more than one material. The sharp increase in the sand content in the sample horizon subjacent to the clay maximum suggests an unconformity in the paleosolum. In a YSP in Adair County, Ruhe (1956) states that the total sand content of less than 6% (> 50 μ) in the horizons above the B2gb are abnormal. He attributed the finer-textured material in the upper paleosolum to sediments washed from the adjacent slopes of a swale on the paleosurface. Fenton (1966, p. 42-47) made a similar interpretation for the sedimentologic characteristics in the YSP from Tama County at site G-402 (Figure 19) as did Hall (1965, p. 31-32) at site C-72 from the Salt Creek, Tama County, area.

In core M15 OC and carbonates were not determined below a depth of 320 inches. However, at 320 inches or 11 inches below the paleosurface of the YSP the pH is 7.0. At the deepest point of sample penetration in the YSP the pH increased

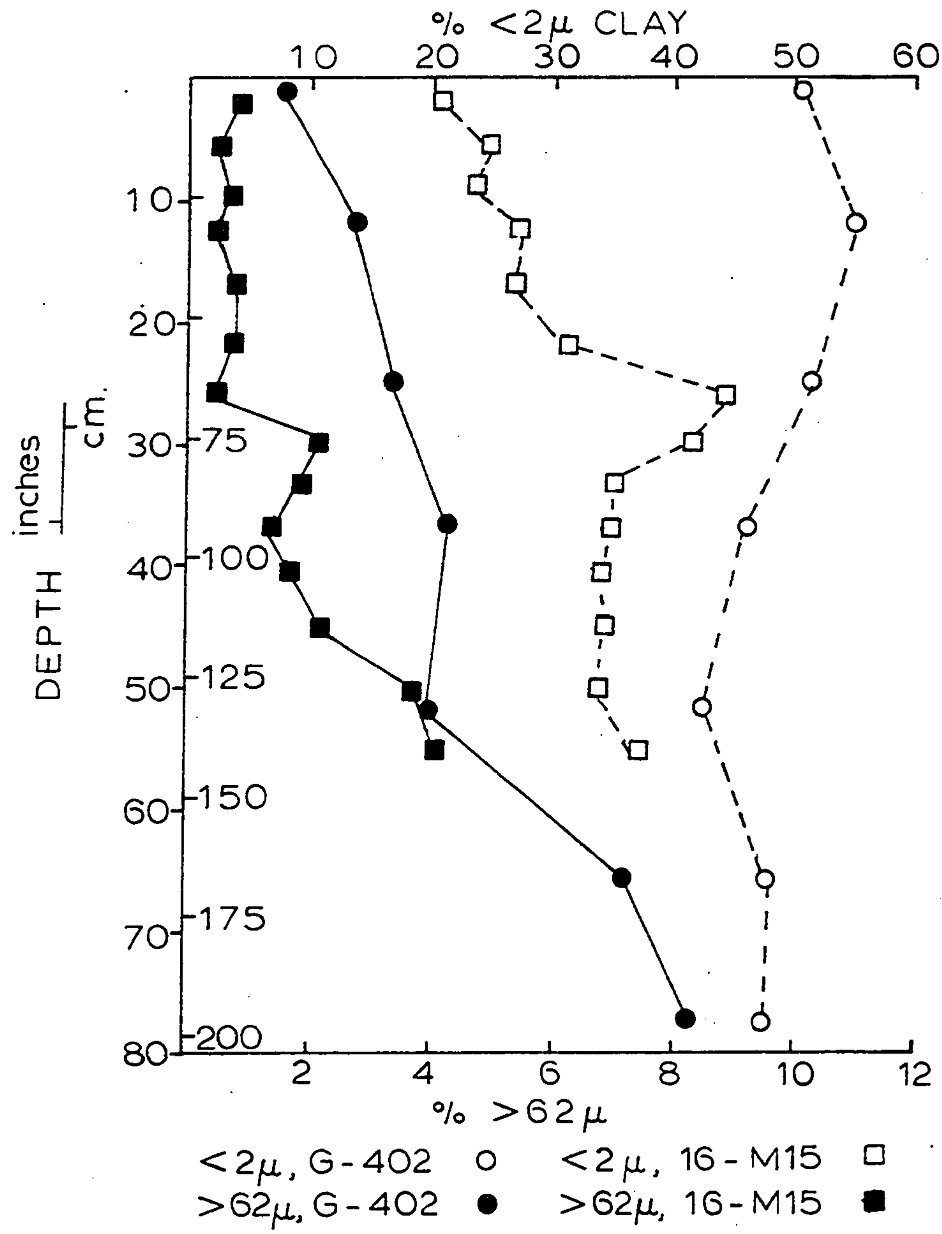


Figure 19. Distribution of clay (< 2 μ) and sand (> 62 μ) versus depth for a YSP from corehole 16-M15 and a YSP from corehole G-402. Profile G-402 from Tama County, Iowa, modified from data in Fenton (1966)

to 7.9. This suggests that the YSP has been enriched by secondary carbonates from the calcareous loess overburden.

Matrix colors of the paleosol in core M15 grade from dark gray (5Y 4/1) at the surface to dark greenish gray (5GY 4/1) at the base. The sample horizon at 28 to 32 inches (Figure 19) has a matrix color of very dark grayish brown (2.5Y 3/2). This sample horizon corresponds to the zone of increased sand content below the clay maximum of 44.5%.

<u>Core 16-M26</u> Core 16-M26 is 6.9 feet below the stable summit of the paha (Figure 17; Appendix A). The thickness of the Wisconsin age deposits is 23.2 feet. The oxidized and leached zone is 9.3 feet thick. A 1-inch sand lens marks the top of the subjacent oxidized and unleached zone. The oxidized and unleached zone consists of alternating sand and silt increments to a depth of 16.1 feet. At 16.1 to 16.6 feet an organic carbon zone occurs. This band marks the stratigraphic break between the oxidized and unoxidized loess. The band contains an abundant quantity of micro-fossils of angiosperms which were tentatively identified as horsetails or sedges.[1] The subjacent unoxidized and leached zone is 3.0 feet thick. The paleosurface of the BWP is 21.6 feet below the ground surface. The subjacent YSP is 23.2 feet below ground surface (Figure 17). The depth of penetration into the YSP was 1.7 feet.

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[1]Farrar, D. R., Ames, Iowa. Information from observation of sample horizon. Private communication. 1973.

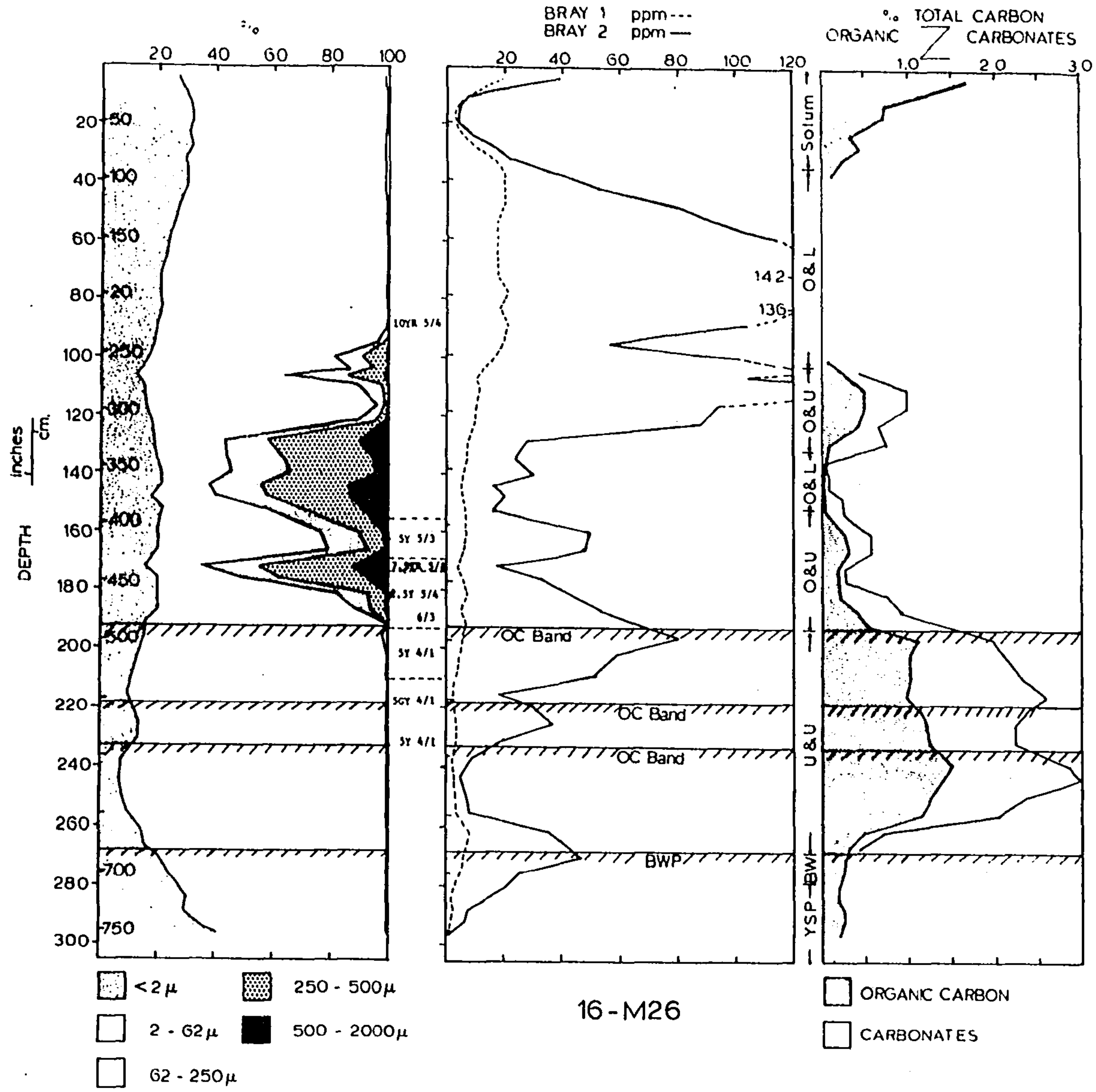
At least three major sand zones can be identified in core 16-M26 (Figures 17 and 20). These zones are separated by bands of finer particles. The greatest percentage of the sand particles are in the medium sand fraction. However, at 129, 144, and 172 inches the coarse and very coarse fractions, 500-2000 μ, contain maximum contents of 10.8%, 14.4%, and 12.4%, respectively.

The distribution of the fractions of silt in core M26 are similar to the silt distribution noted in core M15, except for the oxidized and unleached zone. In core M26 this zone contains intercalated sands. In the latter zone the maximum percentage of silt-sized particles are in both the medium and coarse silt fractions (see core 16-M26, Appendix B). In all other weathering zones in the loess the maximum percentage of silt-sized particles are in the 16-31 μ fraction.

The clay component has a more or less constant distribution in the loess column (Figure 20). Noticeable decreases of clay content correspond to sand content increases. In the unoxidized zone the clay content decreases with depth and reaches a minimum of 6.9% at 242 inches. The increase of clay content below 242 inches is attributed to the relict weathering in the BWP and YSP.

The organic carbon distribution is plotted in Figure 20. A maximum of 1.66% organic carbon occurs at the surface of the ground soil. The organic carbon content increases sharply from 102 to 126 inches (Figure 20). The next marked increase

Figure 20. Distribution of clay (< 2 μ), silt (2-62 μ), very fine and fine sand (62-250 μ), medium sand (250-400 μ), coarse and very coarse sand (500-2000 μ), AP1 (Bray 1), AP2 (Bray 2), OC, and carbonates versus depth for core 16-M26. Munsell colors are given for the dominant matrix colors in the respective weathering zone



%
BRAY 1 ppm ---
BRAY 2 ppm —
% TOTAL CARBON
ORGANIC
CARBONATES
DEPTH
inches
cm.
OC Band
OC Band
OC Band
BWP
Solum
O&L
O&U
O&L
O&U
U&U
BWI
YSP
10YR 5/4
5Y 5/3
5Y 4/1
5GY 4/1
5Y 4/1
< 2 μ
2 - 62 μ
62 - 250 μ
250 - 500 μ
500 - 2000 μ
ORGANIC CARBON
CARBONATES

16 - M26

in organic carbon content is in the material immediately above the 193 to 198-inch sample horizon, the horizon which contains the organic micro-fossils. In this organic band the organic carbon content is 1.12%.

A radiocarbon date was determined for the 193 to 198-inch sample horizon. The date of the organic carbon and micro-fossils in this sample was found to be 21,150 ± 420 years (I-7277).

Below this band at 193 to 198 inches and within the un-oxidized and unleached loess zone the organic carbon maximum is 1.50% (Figure 20). This is in the 234 to 240-inch sample horizon. The OC content decreases sharply within the loess above the BWP as well as within the BWP (Figure 20). An average OC value for the deoxidized and unoxidized zones is 1.07%. In the BWP the average OC content is 0.30%.

The carbonate zone begins at 102 inches in core 16-M26 (Figure 20). A break in the carbonate distribution occurs at 135 inches. This break is marked by a sand zone. The greatest concentration of carbonates is in the deoxidized and unoxidized zones. The average carbonate content is 1.03% or 8.56% calcium carbonate equivalent. The carbonates decrease sharply in the two sample horizons located above the base of the unoxidized zone. The BWP is leached in this core.

In addition to the band of micro-fossils in the 193 to 198-inch sample horizon, two organic carbon bands can be identified in the unoxidized zone (Figure 20). These bands fit the basic depositional model which was previously described.

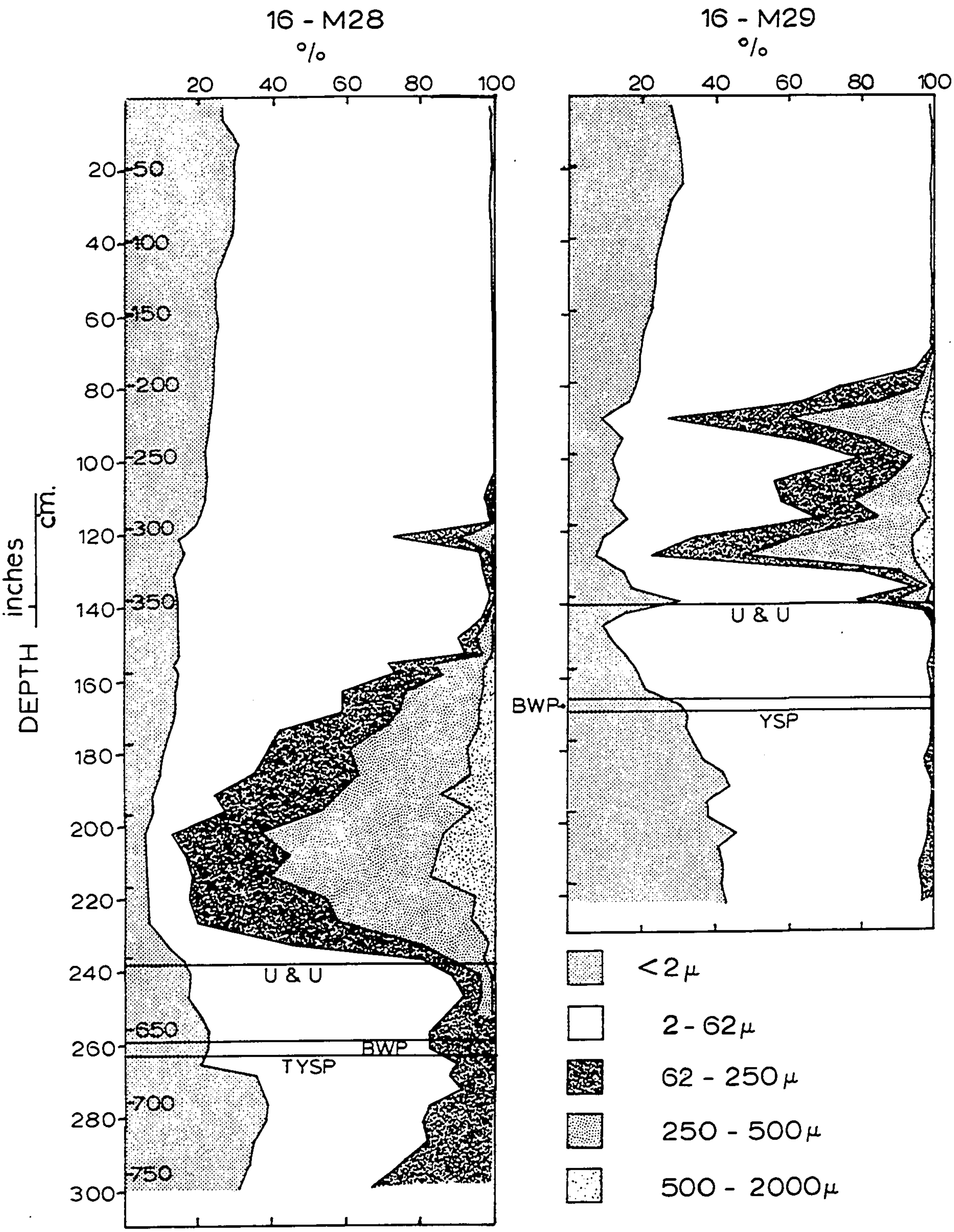
In core M26 the paleosurface of the YSP is at an elevation of 801.8 feet. The physical and chemical characteristics of the YSP are similar to those properties described in core 16-M15 (see cores 16-M15 and M26, Appendix A).

<u>Cores 16-M27 and M29</u> Cores 16-M27 and M29 are located on the linear portion of the paha backslope (Figure 17). The surface of core M27 is 12.9 feet below the paha summit. The surface of core M29 is 16.3 feet below the summit. The thickness of Wisconsinan age materials is less in these cores than in core 16-M26. In core M27, 18.6 feet of loess and sands are above the YSP. In core M29 these units are 14.2 feet thick.

The oxidized zones are present from the ground surface to depths of 12.8 and 12.2 feet for cores M27 and M29, respectively. The unoxidized and unleached zones are 5.1 and 1.1 feet thick. The BWP is present in the form of organic carbon and charcoal flecks in both cores. The YSP was penetrated to depths of 2.8 and 4.7 feet.

In cores M27 and M29 the oxidized loess is approximately 8.0 and 7.0 feet thick, respectively. Below the oxidized loess a complex system of intercalated sands and silts occur (Figure 17). The distribution of the sand, silt, and clay for core M29 is plotted in Figure 21. The sand component has four maximum zones of distribution. These zones occur at depths of 89, 106, 126, and 138 inches. The greatest percentage

Figure 21. Distribution of clay (< 2 μ), silt (2-62 μ), very fine and fine sand (62-250 μ), medium sand (250-500 μ), and coarse and very coarse sand (500-2000 μ) fractions versus depth for coreholes 16-M28 and 16-M29


16 - M28
%
20 40 60 80 100
16 - M29
%
20 40 60 80 100
DEPTH inches / cm.
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
50 100 150 200 250 300 350 650 700 750
U & U
BWP
TYSP
BWP
YSP
<2µ
2 - 62µ
62 - 250µ
250 - 500µ
500 - 2000µ

of sand is in the fine and very fine sand fractions, 62-250 μ. An exception occurs at 126 inches. The medium sand fraction, 250 to 500 μ, contributes the greatest percentage of sand-sized particles in that zone. The sand zone at 138 inches overlies the unoxidized and unleached loess.

The silt component in M29 has a modal distribution of silt-sized particles in the upper portion of the oxidized loess and in the unoxidized loess (see data, Appendix B). The clay content decreases with depth from a maximum of 30.9% at 17 to 26 inches in the ground soil. Less than 10.0% clay is present at two locations of maximum sand-size particles (Figure 21). In the zone immediate above the paleosurface of the unoxidized and unleached loess the clay content reaches a maximum of 29.6%. In the unoxidized and unleached loess the clay content is 9.1% at 146 inches and increases to 20.6% in the sample horizon overlying the BWP.

The complete total carbon distribution was not analyzed for cores M27 and M29. The maximum organic carbon at the ground surface is 1.76%, core M27, and 1.63%, core M29. The organic carbon content in the BWP is 0.31%. Core M29 is leached to a depth of 129 inches. Carbonates are present from 129 to 166 inches. The BWP is leached.

In core M29 a total of 55 inches of the YSP was sampled. The sand, silt, and clay distribution is plotted in Figure 21. The maximum sand content is less than 4.0%. The clay content has a bimodal distribution with maximum values of 43.6 and

45.4%. At the base of the sampling zone the percentage of clay indicates an increasing trend. The YSP paleosurface is at an elevation of 800.4 feet. The paleosurface elevation is 799.4 feet in core M27.

Core 16-M28 Core 16-M28 is 50 feet downslope of core M29 and 19.6 feet below the summit of the paha (Figure 17). The ground surface at this corehole marks the intersection of the linear backslope component and the concave footslope component of the hillslope.

The oxidized and leached zone extends from the ground surface to a depth of 122 inches. The oxidized and unleached zone extends from 122 to 238 inches. The subjacent deoxidized and unleached loess is 28 inches thick and is directly above the BWP. The BWP is 258 to 267 inches below the ground surface. The underlying truncated Yarmouthian-Sangamonian paleosol (TYSP) was penetrated at 267 inches. Oxidized and leached till was identified in this core at a depth of 290 inches.

The sand, silt, and clay distribution of core M28 is plotted in Figure 21. The sand lens at 120 to 122 inches marks the base of the leached zone. Below this sand lens the sand component decreases to 1.5% at 138 inches. The sand-sized particles increase in percentage throughout the subjacent zone and reach a maximum of 87.3% at 202 inches. Below 202 inches the sand decreases to 8.9%. In the sample horizon overlying the BWP the sand increases to 17.6%. The major sand zone in the lower portion of the oxidized zone is 7.1 feet thick.

The medium-sized sand particles have contributed the greatest percentage of particles to the sand component (Figure 21). The distribution of the silt-sized particles is similar to those data shown in adjacent cores. The clay content decreases from a maximum of 30.3% in the 11 to 15-inch sample horizon of the ground soil to 5.2% at 202 inches. This clay minimum corresponds to the sample horizon containing the maximum percentage of sand-sized particles. In the unoxidized and unleached zone the clay content increases to 22.3%.

A total carbon analysis was made for the ground soil and the BWP. The maximum percentage of organic carbon, 2.07%, occurs in the surface of the ground soil. The percentage of organic carbon in the BWP is 0.47%. The BWP is a 3-inch zone consisting of organic carbon bands and charcoal flecks. The upslope lateral extent of this band is unknown (Figure 17). During the collection of core 16-M28 the band was identified in the field description. However, the band was contaminated with lubrication oil from the slotted-tube. Fourteen days later the site was resampled. The band was not identified in the second core. A more accurate measurement was made to locate corehole M28. It was determined that the second core location had been spotted approximately 6 feet south of the initial corehole location. A third core was collected at corehole M28 and the band of organic carbon was identified.

A radiocarbon date found the band to be 17,810 ± 280 y.b.p. (I-7295) (Figure 17).

Carbonates are present in core M28 from 122 to 267 inches. The base of the carbonate zone is the sample horizon subjacent to the BWP.

The TYSP was sampled to a depth of 32 inches. The sand, silt, and clay distribution of the truncated paleosol in core M28 is plotted in Figure 21. The sand component increases from 12.4% at the paleosurface to 33.8% at the base of the core penetration. The maximum clay content, 38.2%, is 12 inches below the paleosurface. The truncated surface of this paleosol is at an elevation of 789.0 feet. This is 11.4 feet below the paleosolic paleosurface in core M29 which is located 50 feet north of this corehole.

The basal sample horizon in core M28 is identified as oxidized and leached till. The matrix color is yellowish brown (10YR 5/8). The matrix colors of the overlying material grades from dark gray to dark greenish gray (5Y 4/1 to 5GY 4/1) in the paleosurface horizon to olive (5Y 4/3 to 5/4) in the sample horizon immediate above the basal sample.

On the lower surface of this hillslope (Figure 17) or on the loess-mantled Iowan surface five cores were collected: 16-M30, M31, M7I, M32, and M7A. Cores M30, M32, and M7A consist of thick loess over oxidized and unleached sand on subjacent oxidized and leached till. Cores M31 and M7I consist of thick loess over oxidized and leached till.

Particle-size data are available only for core M7A and the upper 10.33 feet of M30. The particle-size distribution of core M7A is plotted in Figure 22.

The oxidized and leached, unleached, deoxidized and leached, unleached, zones in the loess, sands, and tills are shown in Figure 17. The loess thickness, thickness of sand zones, and the elevation of the truncated till surface are listed in Table 9.

The gradient of the till surface from core M30 to core M7I, a distance of approximately 425 feet, is less than 0.5%. The gradient from 16-M7I to corehole M32, 450 feet, is also less than 0.5%. Finally, the gradient from M32 to M7A, a distance of 600 feet, is 0.75%.

Lime City transect

The Lime City transect provides for description of the detailed stratigraphy of the unconsolidated material and paleogeomorphic surface that occurs on a secondary interfluve normal to the primary topographic divide. The head of this transect, core 16-M16, is located adjacent to the primary divide (Figures 4 and 6). The ground surface at the tail of the transect, core 16-M40, is 49.0 feet below the head.

This transect contains 10 coreholes. Two, 16-M16 and M17, are located adjacent to the Cedar-Wapsipinicon River divide. Five of the coreholes, 16-M33, M34, M35, M36, and M40, are along the axis of the interfluve, and three coreholes,

Figure 22. Distribution of clay, silt, and sand with depth for corehole 16-M7A

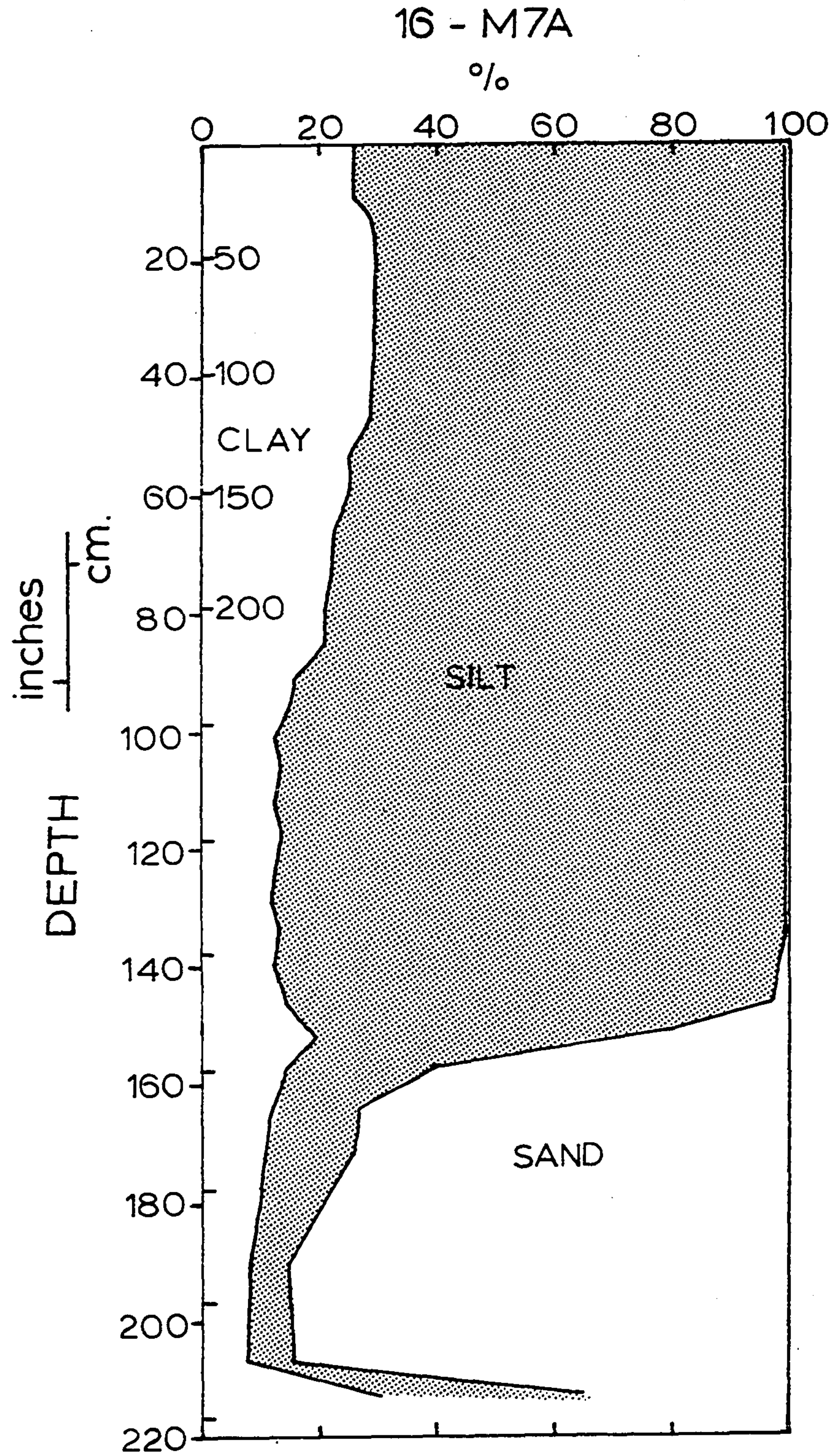

16 - M7A
%
0
20
40
60
80
100
20
50
40
100
CLAY
60
150
inches
cm.
80
200
SILT
100
DEPTH
120
140
160
SAND
180
200
220

Table 9. Loess and sand zone thickness, elevation of the truncated till surface, and matrix color of the till for coreholes in the Iowan erosion surface area, Bennett transect

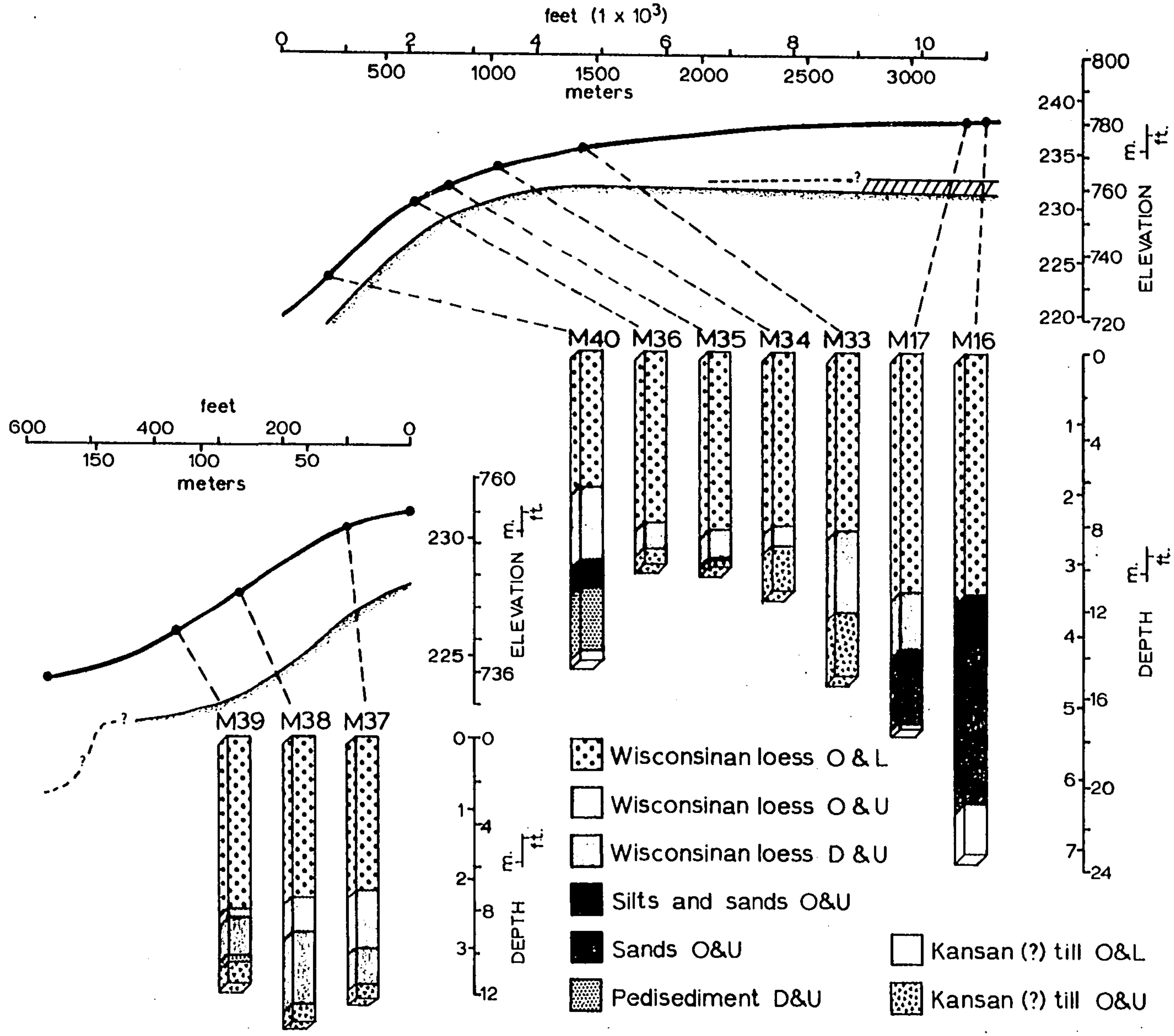
Core	Loess thickness (ft)	Sand zone thickness (ft)	Elevation of till surface (ft)	Matrix color of till
16-M30	17.1	3.42	786.1	2.5Y 5/4
16-M31	16.7	--	786.4	2.5Y 5/4
16-M7I	13.0	--	784.4	5Y 5/3 to 2.5Y 5/4
15-M32	13.9	3.92	782.3	2.5Y 5/4
16-M7A	12.5	5.00	786.3	5Y 5/1

16-M37, M38, and M39, are along the north facing hillslope normal to M36. The elevation, weathering zones, and stratigraphic sequence of materials for these 10 coreholes are plotted in Figure 23.

Laboratory analysis was performed on core 16-M34. Data on all other cores are based on field and laboratory descriptions. The particle-size data for core M34 is listed in Appendix B.

Core 16-M16 is located on a convex knob of 3% slope. The ground soil is a well-drained Mollisol. The loess thickness in this core is 13.3 feet. Subjacent to the loess is 7.4 feet of oxidized and unleached sands over oxidized and leached till. The elevation of the till surface is 760.3 feet. The

Figure 23. Location of coreholes along the Lime City transect with the stratigraphic materials sequence and weathering zones


feet (1 x 10³)
0 2 4 6 8 10
500 1000 1500 2000 2500 3000
meters
800 240 780 235 760 230 740 225 220 720
m. ft.
ELEVATION
M40 M36 M35 M34 M33 M17 M16
0 1 4 2 8 3 12 4 16 5 6 20 7 24
DEPTH
feet
600 400 200 0
150 100 50
meters
760 230 225 736
ELEVATION
M39 M38 M37
0 0 1 4 2 8 3 12
DEPTH
Wisconsinan loess O & L
Wisconsinan loess O & U
Wisconsinan loess D & U
Silts and sands O&U
Sands O&U
Pedisediment D&U
Kansan (?) till O&L
Kansan (?) till O&U

matrix color of the till is light olive brown (2.5Y 5/4).

Core 16-M17 is located 372 feet west of core M16. Core M17 is positioned on the footslope component, upslope to the head of a first-order drainageway. The ground soil is somewhat poorly drained. The surface elevation at this corehole is 772.0 feet (not to scale in Figure 23). The loess thickness is 12.3 feet. A 4.9-foot increment of sand occurs beneath the loess. The till surface subjacent to the sand zone is at an elevation of 758.8 feet. The gradient of the till surface between M16 and M17 is less than 0.5%.

Corehole 16-M33 is located at the head of the interfluve (Figures 6 and 23). The ground elevation is 772.0 feet, 9.0 feet lower than M16 and 4.0 feet lower than M17. The ground soil is a somewhat poorly drained Mollisol. This core contains 12.0 feet of loess over a truncated oxidized and unleached till surface. The till surface is at an elevation of 760.0 feet, which approximates the till elevation in cores M16 and M17. No sands are present at this site.

Corehole 16-M34 is approximately 1325 feet west and downslope of core M33. The surface elevation is 766.0 feet, a reduction of 6.0 feet. The ground soil associated with this core is well drained. The loess thickness if 9.0 feet. The loess overlies oxidized and unleached till which has a matrix color of yellowish brown (10YR 5/4). The elevation of the till surface is 757.0 feet, a net change of 3.0 feet from core M33.

Downslope of core M34, along the axis of the interfluve, the loess thickness has only slight changes. A 0.08-foot sand lens is present at the loess-till interface in core M35. Core 16-M40 is located on the noseslope of the interfluve (Figures 6 and 23). The loess thickness is 9.7 feet. A 1.2-foot zone of intercalated sands and silts are subjacent to the loess. A 3.0-foot increment of pedisediment occurs below the sand and silt zone and is above the oxidized and leached till.

Cores 16-M37, M38, and M39 have stratigraphic sequences similar to those found on the interfluve axis. Loess thickness is 11.5, 12.4, and 10.2 feet, respectively. A 0.3-foot increment of pedisediment occurs in core M39. No sand zones were identified in this transect.

The thickness of the oxidized and leached zone decreases in thickness from the stable secondary divide to the noseslope of the secondary interfluve. At core M16 the oxidized and leached zone is 11.2 feet thick. At core M34 this weathering zone is 8.1 feet and at core M40, 6.3 feet thick. The thickness of this weathering zone in cores M37, M38, and M39 is 7.1, 7.5, and 7.9 feet, respectively. The least thickness of the oxidized and leached zone occurs on the shoulder position. Thickness of the zone increases on the backslope and the greatest thickness is at the footslope position.

Weathering Zones

The weathering profile includes the unconsolidated sediments from the ground surface down to a depth where no *in situ* physical or chemical alteration of the material has occurred. Therefore, weathering zones consist of horizons or layers of material altered from their original state of deposition. The zones differ in physical and chemical properties from each superjacent or subjacent layer. The lowest zone is presumed to be the least altered and is probably the best representative of the original nature of the material.

The differences in weathering zones are inferred from the colors of the sediments. Alteration may include the loss of calcium and magnesium carbonate, weathering of primary minerals, and the removal and rearrangement of iron, manganese, and phosphorus, as well as other elements.

Weathering zones are present in the loess and till of eastern Iowa. The nomenclature used in describing weathering zones in this study is similar to that used by Ruhe (1954) and later summarized in his text (Ruhe, 1969a). Fenton (1966, p. 119) outlined a brief description of the weathering zones identified in the Wisconsinan loess of east-central Iowa. The descriptive terminology used in this study is in accordance with his outline.

Distribution of weathering zones

Thick loess-mantled Yarmouth-Sangamon area The distribution of the weathering zones of the Wisconsinan loess was studied in detail in the Bennett transect. The transect begins with core 16-M15 on the summit of the paha and includes continuous core samples from coreholes 16-M26, M27, and M29.

The sequence of weathering zones for Wisconsinan age materials in cores M15 and M26 are listed in Table 10. Three other cores, 16-M19, M22, and M24, contain similar weathering zone profiles (Tables 5 and 8). Detailed laboratory analyses were not performed on cores M19 and M22. The identification of all weathering zones in these cores may be incomplete. The results reported in the following paragraphs will be limited to cores 16-M15, M26, M27, M29, and M24.

The weathering zone sequence is similar for all cores, but cores M26, M27, and M29 are the most complex because of the intercalated sand zones. The upper portion of each of these cores is leached. The depth to carbonates is greatest, 10.6 feet, in core M29. Subjacent to the oxidized and leached zone is the oxidized and unleached zone consisting of loess and/or sands. With the exception of core M26 the remainder of the Wisconsinan age materials are unleached above the BWP. In core M26 a leached zone of intercalated sands occurs between 126 and 151 inches (Figure 20).

The boundaries marking the oxidation zones are distinct. The interface between the oxidized and deoxidized or unoxidized

Table 10. Weathering zones for Wisconsinan aged materials in cores 16-M15 and 16-M26

16-M15	16-M26
Surficial soil	Surficial soil
Oxidized and leached loess	Oxidized and leached loess
Oxidized and unleached loess	Oxidized and unleached sands
Deoxidized and unleached loess	Oxidized and unleached loess
Oxidized and unleached loess	Oxidized and leached sands
Deoxidized and unleached loess	Oxidized and unleached loess
Organic band	Oxidized and unleached sands
Unoxidized and unleached loess	Oxidized and unleached loess
Organic band	Organic band
Unoxidized and unleached loess	Unoxidized and unleached loess
Basal Wisconsinan paleosol	Basal Wisconsinan paleosol

zone is marked by a series of fine bands of manganese and iron oxides. In all cases observed the lowermost band of manganese concretions occur above the uppermost band of iron concretions. The manganese zones result in a "salt and pepper" colored matrix of olive gray (5Y 5/2) and very dusky red (2.5YR 2/2). The iron oxide band generally has a solid matrix color of strong brown (7.5YR 5/8) to yellowish brown (10YR 5/8).

A 3 to 5-inch organic band, rich in partially decomposed plant materials, occurs in the uppermost portion of the unoxidized zone in core M26. To the knowledge of this writer this is the first time an organic enriched band, other than the time-transgressive BWP, has been identified as occurring at the oxidized-unoxidized interface in loess deposits in the state of Iowa.[1] A radiocarbon analysis of this organic material from core M26 (Figure 17) resulted in a date of 21,150 ± 420 years (I-7277).

In core M15 the zone below the oxidized loess is deoxidized. This deoxidized zone overlies an oxidized zone. The lower oxidized zone is above a deoxidized zone which is immediately above the unoxidized zone (Figure 17). In core M24 an oxidized zone occurs between the deoxidized and unoxidized loess (Table 7). The unoxidized zone in cores M15, M24, and M26 is rich in organic carbon (Figures 18 and 20; Appendix A). The matrix color of the unoxidized zone is dark greenish gray (5GY 4/1). Carbon flecks and streaks of black (5Y 5/1 and N 2/0) are randomly distributed throughout the matrix of this zone. In all three of these cores the unoxidized zone is superjacent of the BWP. The BWP was dated at 25,100 ± 700 years (I-6750) in core M15.

In the Bennett paha an erosional unconformity occurs. This unconformity is denoted in Figure 17 by the solid heavy line drawn along the loess-till contact and extending upward into the paha interior. This unconformity cuts across the

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[1]Ruhe, R. V., Bloomington, Indiana. Information from personal observations. Private communication. 1972.

oxidized and unleached zone in M26. In cores M27 and M29 the unconformable surface marks the interface between the oxidized and unoxidized zones. No deoxidized zone was identified in these coreholes.

Thick loess-mantled Iowan surface   The distribution of weathering zones in the Wisconsinan loess on the Iowan surface was studied in coreholes from the reconnaissance traverse, the southern portion of the Bennett transect and in the Lime City transect.

In a subsequent section entitled surfaces the characteristic features and stratigraphic relationships of the thick loess-mantled Iowan surface will be described. Briefly, this Iowan surface consists of 12.4 to 18.0 feet of loess over a truncated till surface. The till surface is inset below the YSP and the YSS. At some sites on the Cedar-Wapsipinicon River divide an increment of sands occur between the loess-till interface.

Weathering zones within the loess and sands of the thick loess-mantled Iowan surface include oxidized and leached, oxidized and unleached, deoxidized and leached, and deoxidized and unleached (Figures 12 and 17). No organic bands were identified.

An upper oxidized and leached zone was identified in all cores collected from sites on the Iowan surface. The upper oxidized and leached zone is superjacent to either an oxidized and unleached zone or a deoxidized and leached or unleached zone (Tables 5 and 8; Figures 12 and 17). A deoxidized and leached zone was identified in only one corehole, 16-M7I. The landscape position of this corehole is a swale. In coreholes 16-M9, M12, and M20 (Tables 5, 7, and 8) an oxidized and leached zone occurs below the oxidized and unleached zone. This lower oxidized and leached zone is associated with sediments having a matrix of sand-sized particles.

Loess-mantled Iowan surface The distribution of weathering zones of the Wisconsinan loess on the loess-mantled Iowan surface was studied in cores 16-M18, M23, and M41. These coreholes are located within the area previously defined as the Iowan erosion surface (Figure 2). Weathering zones within the loess and sands of this area were oxidized and leached (Figure 9). No organic bands were identified.

Chemical characteristics

The distribution of organic carbon, carbonates, and pH in the weathering zones have been discussed in a previous section. Available phosphorus, Bray 1 (AP1) and Bray 2 (AP2), were determined on sample horizons in cores 16-M15 and M26. The purpose of these analyses were threefold: (1) to study the variation in distribution of available phosphorus in different weathering zones, (2) as an experimental analysis to investigage the more soluble forms of phosphorus in the weathering profile, and (3) to evaluate translocations of phosphorus which occur in the weathering profile.

A detailed review of the soluble and other forms of phosphorus in the weathering profile is outlined in the background section.

The distribution of AP1 was determined for cores M15 and M26 as well as for many other cores in this study. The general distribution of AP1 is similar for all cores. The maximum AP1 is in the A horizon of the ground soil followed by a sharp decrease in the A3-B1 horizon. The maximum accumulation occurs in the textural B horizon or near the base of the B horizon of the ground soil. Below the solum the AP1 values decrease as the sample horizons approach the unleached zone of the weathering profile. The AP1 values are seldom greater than 10 ppm in the unleached zone (see data in Appendix B). Figure 18 shows the comparison of AP1 and AP2 for core M15.

The distribution of AP2 for cores M15 and M26 is plotted in Figures 18 and 20. The minimum AP2 content occurs in the A3-B1 horizons of the ground soils and in the basal unoxidized and unleached zone of the loess. Maximum AP2 values are below the textural B2 horizon of the ground soil.

In core M15 the AP2 decreases sharply subjacent to the surface of the unleached zone. A second decrease occurs at a depth of 130 inches. This sample horizon has an increase in content of organic carbon and carbonates. The third major decrease in AP2 occurs at 178 inches. This is the upper boundary of the unoxidized zone. Slight variations of AP2 occur in the unoxidized zone with minimum AP2 values being superjacent to the upper surface of the BWP and at the BWP-YSP interface. The latter contact is at 306 inches (Figure 18). The AP2 values increase in the Ab horizon of the YSP, at 306 to 309 inches, and decrease in the A2b horizon, at 333 to 344 inches (Figure 18).

In core M26 the AP2 distribution has a sharp decrease at 98 inches (Figure 20). This sample horizon is just above the unleached-leached interface. Below this leaching contact the core contains an increased percentage of sand-sized particles. Within the upper unleached zone, at 104 to 108 inches, the distribution of AP2 increases. A decrease occurs in the subjacent unleached sand zone. The basic distribution model of AP2 in this oxidized zone is (1) an increase of AP2 at the uppermost textural change, followed by (2) a decrease of AP2 values in the coarser textured zones and (3) an increase in AP2 values at the surface of zones containing finer textured deposits. The variations of AP2 at textural boundaries are of the magnitude of 2.0 and 2.5-fold.

At 193 to 198 inches in core M26 the AP2 distribution increases sharply in the organic band at the surface of the unoxidized zone (Figure 20). In the subjacent weathering zone the AP2 distribution decreases to less than 20 ppm. An increase occurs between 212 and 228 inches. This increase corresponds to an increase in the $< 2\ \mu$ clay and organic carbon. The final variation in distribution is a decrease of

AP2 to 5.0 ppm at 291 inches. This decrease is followed by an accumulation of AP2 above the BWP and then the AP2 reaches a maximum of 42.5 ppm within the BWP (Figure 20).

Surfaces

A surface is a two-dimensional form having length and width which is independent of thickness. A geomorphic surface is a mappable feature that may be depositional or erosional, or both. It is "a portion of the landscape specifically defined in space and time" (Ruhe, 1969a). It my include only one unit of material or it may cut across several units.

This section is designed to report a generalized description of the different geomorphic surfaces identified in the Cedar-Scott counties study area. Each surface is identified according to the informal nomenclature used by Pleistocene researchers in the state of Iowa. The description of these surfaces and the names by which these surfaces are identified are intended to be applicable only within the study area.

Bedrock

The bedrock surface is subjacent to the unconsolidated sediments. This surface was contacted in coreholes 16-M13, M14, and M41. The bedrock topographic characteristics were reported in the bedrock section and are discussed in the discussion section.

Yarmouth-Sangamon

The Yarmouth-Sangamon surface is formed by the YSP on the till plain. This surface is characterized by the presence of an intensively weathered paleosol. The stratigraphy and characteristics of the paleosolum are described in the description of the Bennett paha. This surface is at an elevation ranging from 805.2 feet, core M15, to 799.3 feet, core M27. A vertical change of 5.9 feet occurs over a lateral distance of more than 700 feet (Figure 17).

Late Wisconsinan

The Late Wisconsinan surface is identified by the organic band which is located along the weathering zone interface in corehole M26. A radiocarbon sample collected at the surface and to a depth of 5 inches subjacent to this surface yielded a date of 21,150 ± 420 years (I-7277). This sample horizon is 80 inches above the BWP in corehole M15 which yielded a date of 25,100 ± 700 years (I-6750). This suggests that 80 inches of basal loess in the Bennett paha accumulated in approximately 3,950 years.

Iowan

The surface identified as the Iowan erosion surface has a set of stratigraphic and topographic parameters which meet the requirements of the Iowan erosion surface reported for east-central Iowa (Ruhe et al., 1968). These parameters are listed in the discussion section.

The Iowan surface has cut the Late Wisconsinan organic band and stripped the Late Sangamon, Yarmouth-Sangamon, and other pre-Wisconsin aged paleosols, if any, in the study area. This surface has cut below these paleosols into the weathering zones of subjacent till. Figure 17 shows the relationship of this surface to the Yarmouth-Sangamon surface. At site M28 the YSP has been truncated. At corehole M29 no truncation has occurred. Also, this surface cuts across depositional sediments superjacent to the YSP in coreholes M29, M27, and M26.

The lower level Iowan surface to the south and southwest of the Bennett paha is an erosional surface cut below the Yarmouth-Sangamon surface. As reported in a previous section the gradient of this surface in the Bennett transect and Sunbury Flat area is less than 1.0%.

Thick loess-mantled Yarmouth-Sangamon

This surface is the highest surface and occurs on the stable upland summits which are controlled by the Yarmouth-Sangamon surface. In the Bennett paha and at sites 16-M19, M22, and M24 this surface is superjacent to loess which has a thickness of 25.2 to 29.7 feet. These increments of loess represent the total thickness of loess deposited in this area during Wisconsinan time. A radiocarbon date in the Bennett paha yielded a basal loess date of 25,100 ± 700 years (I-6750). Less stable hillslopes controlled by the Yarmouth-Sangamon surface have reduced increments of loess thickness because of surface removal and hillslope retreat.

<u>Thick loess-mantled Iowan</u>

The lower surface in the Bennett transect, in the Sunbury Flat area, and in the Lime City transect are located on stable upland interfluves. This surface is underlain by a thick mantle of loess over truncated till or thick loess above sands which overlie truncated till. This surface is controlled by sands on the truncated till surface or by the till surface itself. The thickness of the loess ranges from 12.0 to 18.4 feet.

This surface abuts the loess-mantled Yarmouth-Sangamon surface in the Bennett transect. A basal loess radiocarbon date at site 16-M28 yielded a date of 17,810 ± 280 years (I-7295). This suggests that the surface was cut some time subsequent to 21,150 and accumulation of loess commenced subsequent to 17,810 YBP.

In the Lime City transect a truncated till surface was identified. At site 16-M40 the elevation of the till surface is 732.0 feet. At site 16-M33 the elevation of the till surface is at 772.0 feet. The loess thickness at site 16-M40 is 9.0 feet.

Loess-mantled Iowan

Coreholes 16-M18, M23, and M41 are located on the thin loess-mantled Iowan erosion surface. The loess thickness at these stable summit positions is 5.6, 2.8, and 4.3 feet. This surface is identified by being within the boundaries of the previously defined Iowan surface (Figure 2).

Soils

A total of 29 soil profiles were collected from the study area. Detail morphological descriptions were written and laboratory analyses were performed on sample horizons from these profiles. Eleven of these profiles represent well or moderately well drained soils collected from areas other than the Bennett transect. Fifteen profiles were sampled in the Bennett transect.

One objective of the soils study was to identify similarities and differences in like soils across loess parent materials. The well and moderately well drained prairie-derived soils were characterized on the basis of selected physical and chemical properties. A preliminary evaluation was made of the results obtained from the characterization studies. Soil profiles were partitioned into groups on the basis of their similarities. The criteria for grouping these profiles consisted of three sets of characteristics which can be identified and qualitatively estimated in the field. These characteristics were the amount and distribution of OC, amount and distribution of clay, and dominant morphological characteristics such as matrix colors of the B horizon.

Table 11 presents a listing of the identifying profile number, drainage class, the surface from which the profile was collected, depth to mottling, the presence or absence of neo-skeletans, depth to carbonates, and depth to underlying sands.

Soil groups

Soil group No. 1 consists of well drained soils which occur on gently sloping convex summits. These soils occur on the thick loess-mantled Iowan surface at locations other than within the Sunbury Flat area. The soils in this group have mollic epipedons with 0.58% OC to depths of 19 to 22 inches. The B/A clay ratios range from 1.20 to 1.31 and clay maximums range from 32.0 to 34.0% and occur at depths of 19 to 23 inches below the ground surface. The dominant matrix color in the B horizon is brown (10YR 4/3). Representative profiles include 16-M21, M34, and 82-M1.

Soil group No. 2 consists of well and moderately well drained soils which occur on nearly level to gently sloping convex summits. These soils occur at locations on the thick loess-mantled Iowan surface within the Sunbury Flat area. These soils have mollic epipedons that contain 0.58% OC to depths of 20 to 26 inches. The B/A clay ratios range from 1.16 to 1.37 and maximum clay contents range from 31.0 to

Table 11. Soils and related soil characteristics of the study area

Profile	Drainage class	Parent material[a]	Depth to gray mottles (in.)	Neo-skeletans present	Depth to carbonates (in.)	Depth to sand zone (in.)
			Reconnaissance traverse			
16-M1	Mod. well	TLMI	26	X	117	168
16-M3	Well	TLMI	41	X	122	126
16-M4	SW poorly	TLMI	13	-	>165	-
16-M5	Well	TLMI	40	X	120	-
16-M6	Well	TLMI	42	X	113	140
16-M7A	Mod. well	TLMI	29	X	82	154
16-M8	Well	TLMI	45	X	130	158
16-M9	SW poorly	TLMI	22	-	102	121
16-M18	Well	LMI	47	X	127	56
16-M21	Well	TLMI	43	-	61	-
16-M24	SW poorly	TLMYSP	21	-	87	-
16-M41	Well	LMI	51	X	87	51
82-M1	Well	TLMI	42	X	84	-
			Bennett transect			
16-M7B	Well	TLMI	34	X	-	>125
16-M7C	Well	TLMI	32	X	-	>125
16-M7D	SW poorly	TLMI	27	X	-	>125

[a]TLMI = thick loess-mantled Iowan; LMI = loess-mantled Iowan; TLMYSP = thick loess-mantled Yarmouth-Sangamon paleosol.

Table 11. (Continued)

Profile	Drainage class	Parent material	Depth to gray mottles (in.)	Neo-skeletans present	Depth to carbonates (in.)	Depth to sand zone (in.)
Bennett transect (continued)						
16-M7E	SW poorly	TLMI	13	X	-	173
16-M7F	SW poorly	TLMI	12	X	-	>100
16-M7G	SW poorly	TLMI	11	-	-	-
16-M7H	Poorly	TLMI	12	-	-	-
16-M7I	Poorly	TLMI	14	-	-	-
16-M7J	Poorly	TLMI	21	-	-	-
16-M7K	Poorly	TLMI	20	-	-	-
16-M26	Well	TLMYSP	39	X	102	126
16-M27	Well	TLMYSP	26	X	117	84
16-M28	Well	TLMYSP	23	X	120	120
16-M29	Well	TLMYSP	32	X	129	83
16-M30	Well to SW poorly	TLMI	31	X	-	81
		Lime City transect				
16-M34	Well	TLMI	51	X	87	-

34.0% and occur at depths of 38 to 47 inches below the ground surface. The dominant matrix color in the B horizon is brown (10YR 4/3 to 5/3) with ped coatings of light gray (10YR 7/1). Representative profiles include 16-M1, M3, M6, and M8.

Soil group No. 3 consists of well drained soils which occur on nearly level to gently sloping surfaces having gradients of 2% or less. These soils are located on the thick loess-mantled Iowan surface in the Sunbury Flat area and on the loess-mantled Iowan surface in northern Cedar County. These soils have mollic epipedons that contain 0.58% OC to depths of 16 to 27 inches. The B/A clay ratios range from 1.18 to 1.33 and maximum clay contents range from 28 to 30% and occur at depths of 25 to 32 inches. The dominant matrix colors in the B horizon are brown (10YR 4/3 and 5/3) and dark yellowish brown (10YR 4/4). Representative profiles include 16-M5, M18, and M41.

In addition to these three soil groups soils from the Bennett transect were studied. This study consisted of 11 soil profiles located along a transect on the thick loess-mantled Iowan surface. These profiles are distributed across a 2% slope gradient and represent well, moderately well, somewhat poorly, and poorly drained soils. In addition, the study consisted of five soil profiles located on the thick loess-mantled YSS. These five profiles are distributed across a 6 to 8% slope gradient located on the thick loess-mantled YSS. These profiles represent well and moderately well drained soils.

The results of the soils study are reported by presenting plots of composite data for selected profiles from each of the three soil groups. In addition to the morphological characteristics, clay and OC data, results of the analysis for available phosphorus, pH, CEC, and EA are reported in this section.

The results of the analysis obtained for the Bennett transect are reported by presenting: (1) plots of the profile distribution of selected laboratory analysis for profiles representing each drainage class located on the thick loess-mantled Iowan surface, (2) plots of univalued results for each of the 11 profiles from the thick loess-mantled Iowan surface, (3) plots of profile distribution of OC, clay, and AP1 for soils on the thick loess-mantled YSS.

Characteristics of group No. 1 soils

Morphological characteristics The thickness of the horizons dominated by mollic colors in profiles 16-M21, 16-M34, and 82-M1 are 17, 19, and 19 inches, respectively. Matrix colors in the B horizon are brown (10YR 4/3). Yellowish brown (10YR 5/4) matrix colors are at a depth of 29, 22, and 42 inches. Some light gray (10YR 7/1) ped coatings are present in the B horizon of profiles 16-M34 and 82-M1. Moderate medium subangular blocky structure is predominant in the B horizon of each profile.

Clay The profile distribution of the percentage of < 2 µ clay is plotted in Figure 24 for profiles 16-M21, M34, and 82-M1. In these three profiles the maximum clay is 34.2, 32.4, and 33.2% at 19, 24, and 22 inches, respectively. The B/A clay ratios are 1.26, 1.21, and 1.31. Weighted clay values from 10 to 40 inches are 31.3, 30.9, and 31.3%.

Available phosphorus, Bray 1 Available phosphorus distribution for these profiles is plotted in Figure 25. The minimum values are 7.0, 7.7, and 6.2 ppm at depths of 19, 20.5, and 14 inches. Maximum B values of 32.0, 35.0, and 33.6 ppm occur at depths of 32, 33.5, and 35 inches.

Cation exchange capacity The profile distribution of CEC expressed in meq/100 g is plotted for profiles 16-M21 and M34 in Figure 26. The maximum CEC for profile 16-M21 is 28.5 meq/100 g at 41 inches. The minimum CEC in the solum is 22.3 meq/100 g at 19 inches. The maximum CEC for profile 16-M34 is 24.5 meq/100 g at a depth of 33.5 inches. The minimum solum value, 20.7 meq/100 g, is at a depth of 9 inches.

Weighted CEC values in the 0 to 15-inch zone are 24.9 meq/100 g for M21 and 21.8 meq/100 g for M34. The weighted values for the 10 to 40-inch zone of the sola provided results of 25.2 and 23.1 meq/100 g, respectively.

pH The pH distribution for the three profiles is plotted in Figure 26. The pH approaches 7.0 in the surface horizons of profiles 16-M21 and M34. However, the maximum surface pH in profile 82-M1 is 5.7. Minimum pH values occur

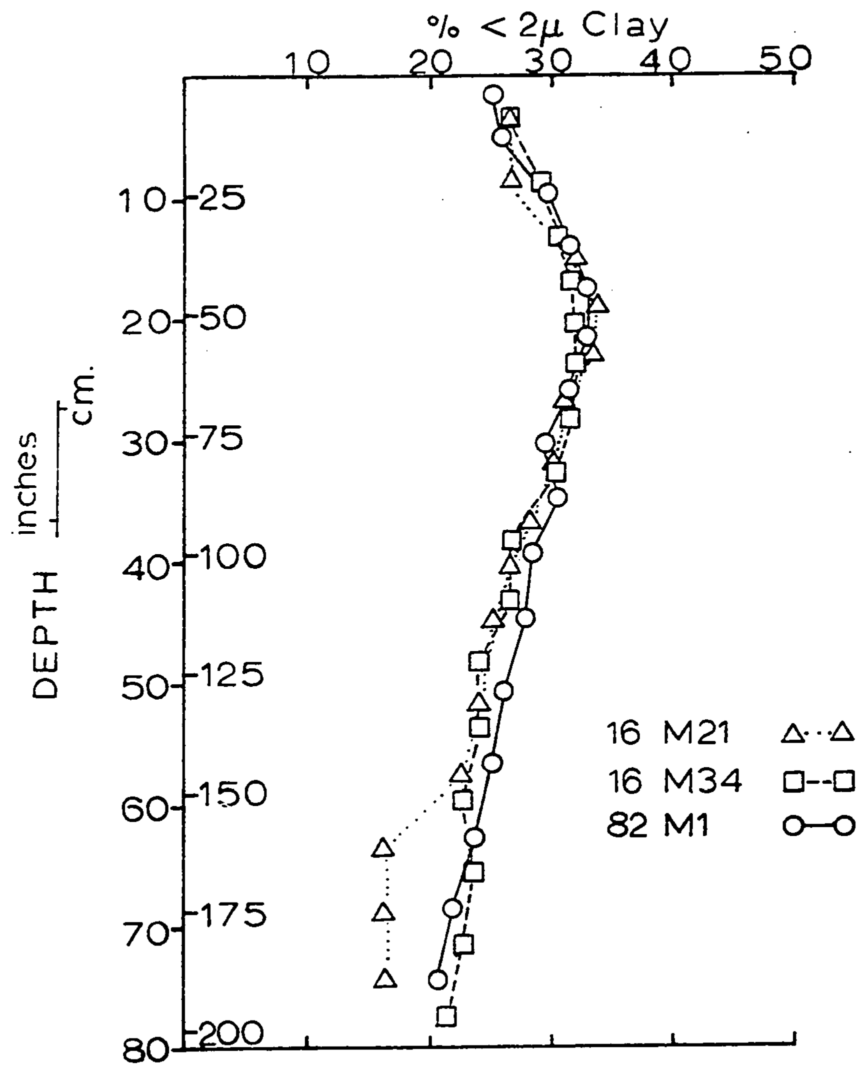


Figure 24. Clay distribution versus depth for soils of soil group No. 1

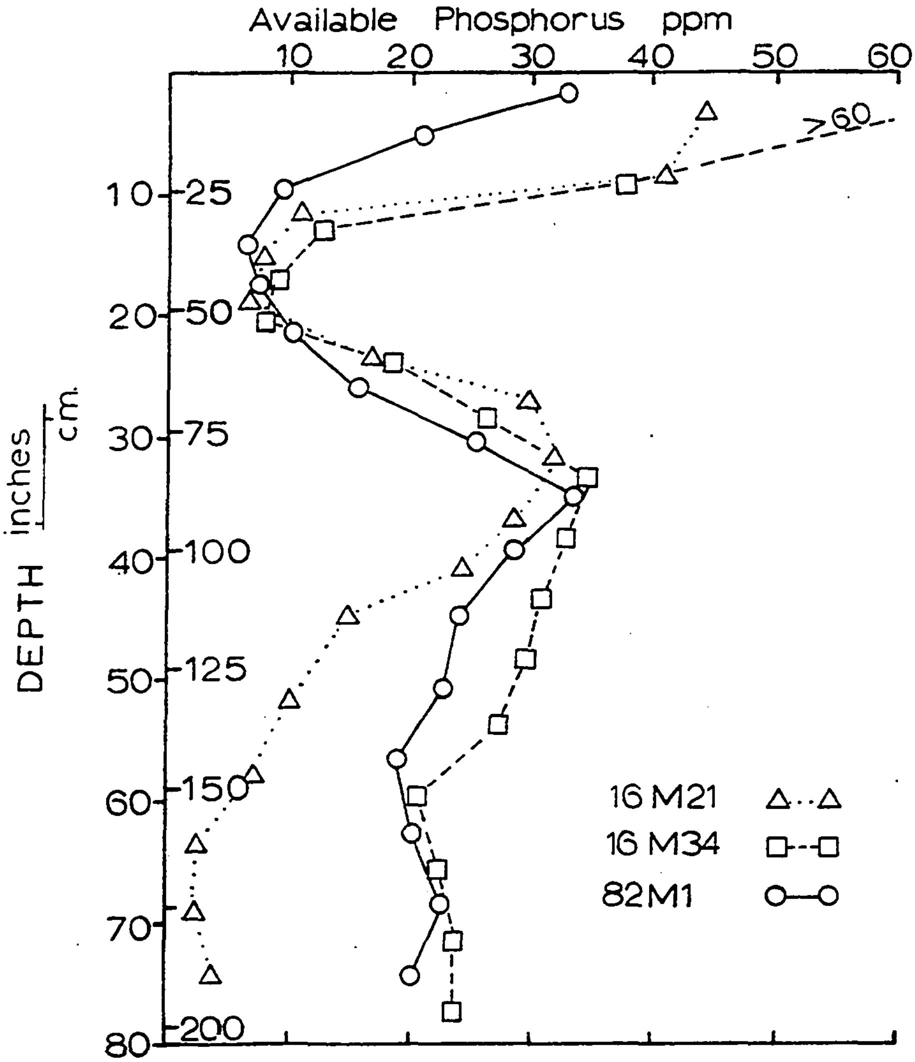


Figure 25. AP1 distribution versus depth for soils of soil group No. 1

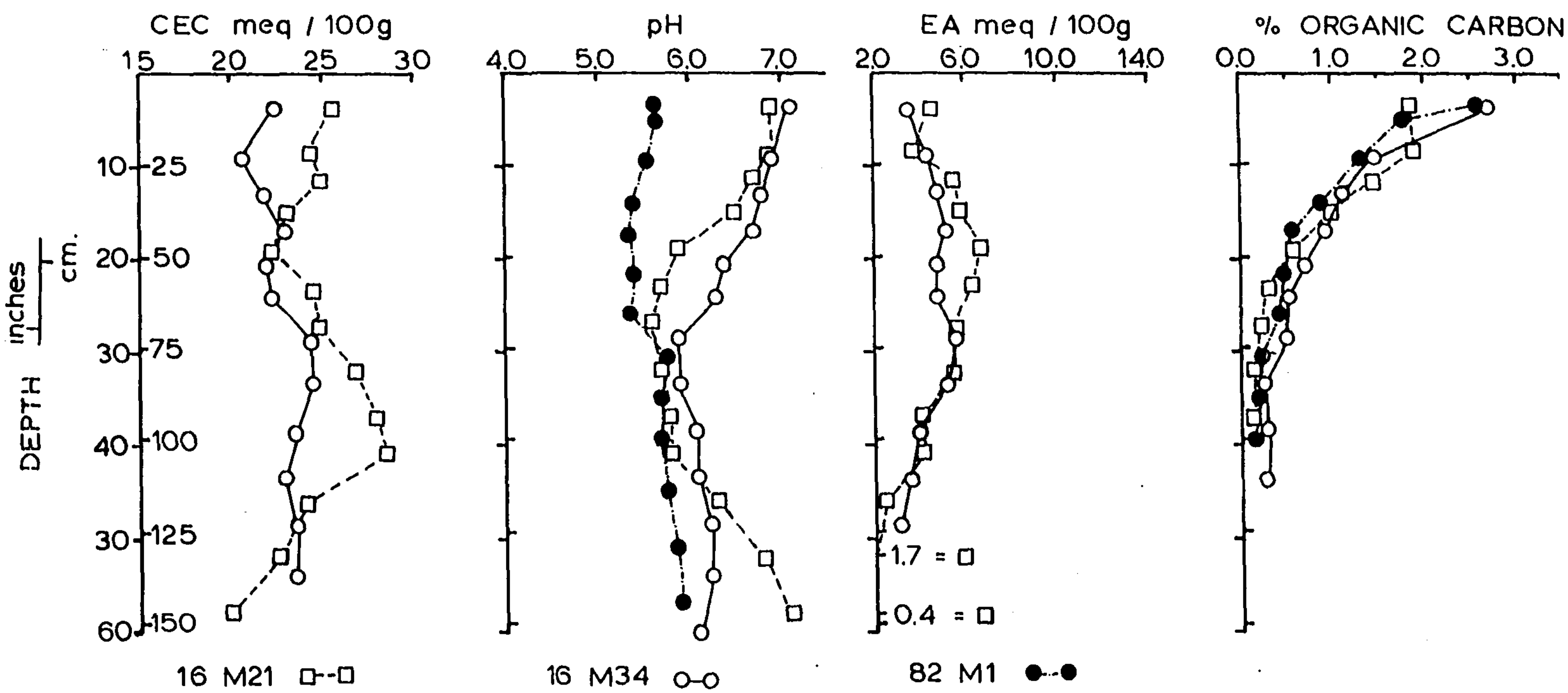


Figure 26. CEC, pH, EA, and OC distribution versus depth for soils of soil group No. 1

in the 25 to 35-inch zone in profiles M21 and M34. The minimum pH zone in profile 82-M1 is from 15 to 28 inches.

Carbonates are present at 61 inches in profile 16-M21. The depth to carbonates in profile 16-M34 is 87 inches and in profile 82-M1, 90 inches.

Exchangeable acidity The exchangeable acidity distribution for profiles 16-M21 and M34 is plotted in Figure 26. The EA values reflect a general inverse of the pH distribution, except that the maximum EA zone in profile 16-M21 is higher in the solum than in the minimum pH zone. The weighted 0 to 15-inch EA values are 4.8 and 4.1 meq/100 g for M21 and M34, respectively. The weighted 10 to 40-inch zone yields EA values of 5.6 and 4.9 meq/100 g.

Organic carbon The percentage of OC is plotted against depth in Figure 26 for the three profiles. The depth to 0.58% OC is 21, 22, and 19 inches for profiles 16-M21, M34, and 82-M1, respectively.

Characteristics of group No. 2 soils

Morphological characteristics The thickness of the horizons dominated by mollic colors in profiles 16-M1, M3, M6, and M8 are 16, 18, 21, and 20 inches, respectively. Matrix colors in the B horizon are brown (10YR 4/3 to 5/3) with light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/4) dominating the lower B horizon. At depths of 26 to 35 inches each of these profiles have thick ped coatings of light gray (10YR 7/1) colors. The structure in the 8 to 24-inch zone is weak fine subangular blocky. In the lower B horizon, from 24 to 40 inches, fine to medium prismatic structure is present.

<u>Clay</u> The profile distribution of the percentage of < 2 µ clay is plotted in Figure 27 for profiles 16-M1, M3, M6, and M8. In these four profiles the maximum clay is 34.3, 32.1, 31.5, and 32.8%. The depth to maximum clay content is 41, 38, 44, and 47 inches. The B/A clay ratios are 1.37, 1.27, 1.16, and 1.23. The weighted clay values for 10 to 40 inches are all less than 30.0%. These values are 28.9, 29.2, 29.7, and 29.5%.

<u>Available phosphorus, Bray 1</u> The available phosphorus distribution for the four profiles is plotted in Figure 28. The minimum AP1 values are 2.5, 3.7, 4.7, and 3.5 ppm at 23, 20, 23, and 23 inches. The maximum AP1 values in the B horizon are 42.5, 23.5, 37.5, and 28.0 ppm. The depth to the AP1 maximum values in the B horizon is 54, 34, 55, and 71 inches. The latter depth in profile 16-M8 is well below the base of the textural B horizon.

<u>Cation exchange capacity</u> The CEC distribution for the four profiles is plotted in Figure 29. Minimum CEC values are at depths of 12 to 20 inches. The maximum CEC values are closely associated with the maximum clay percentage. Weighted CEC values in the 0 to 15-inch zone are 20.6, 20.2, 21.0, and 19.9 meq/100 g. The weighted CEC values for the 10 to 40-inch zone are 19.9, 19.4, 19.9, and 19.1 meq/100 g. All of

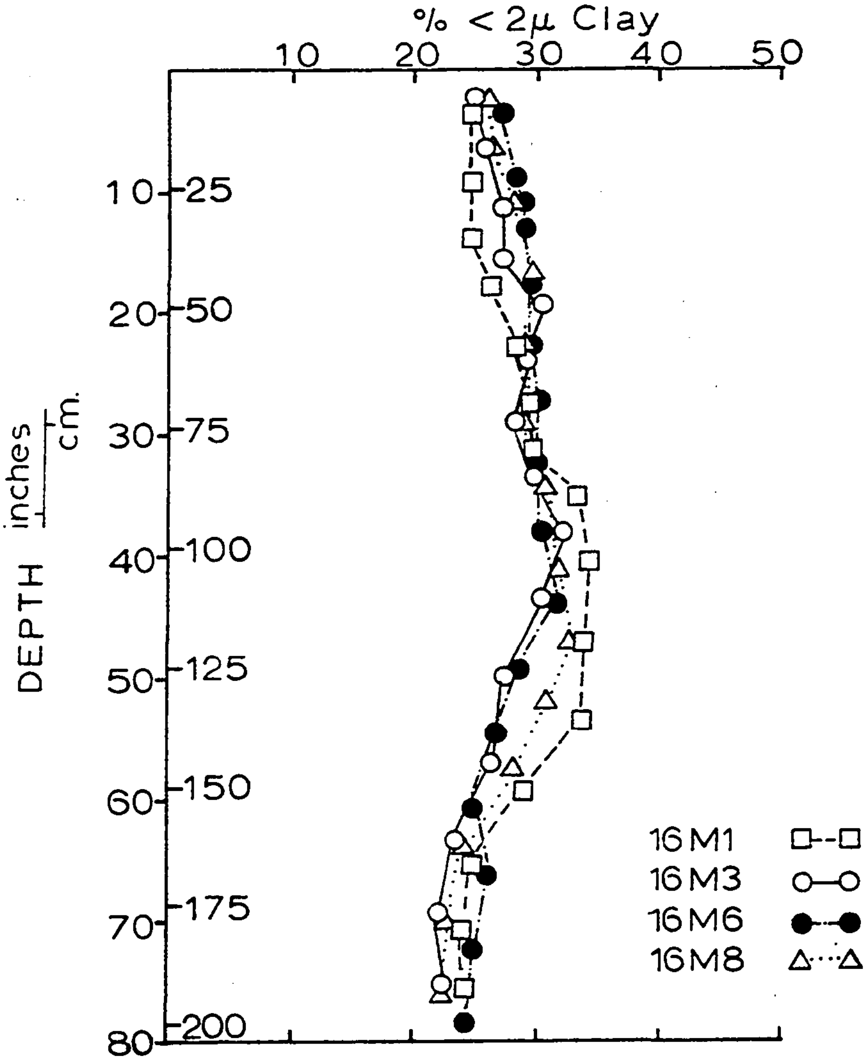


Figure 27. Clay distribution versus depth for soils of soil group No. 2

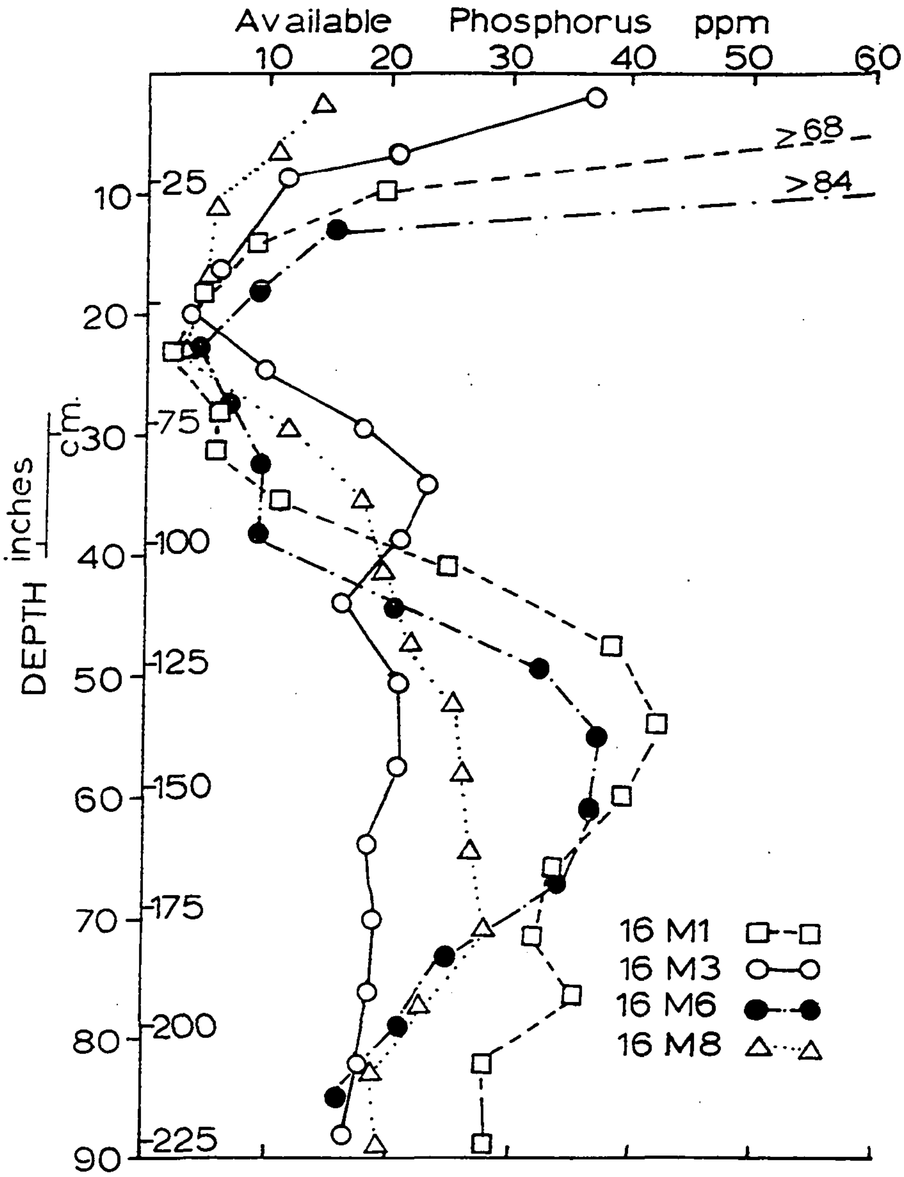


Figure 28. AP1 distribution versus depth for soils of soil group No. 2

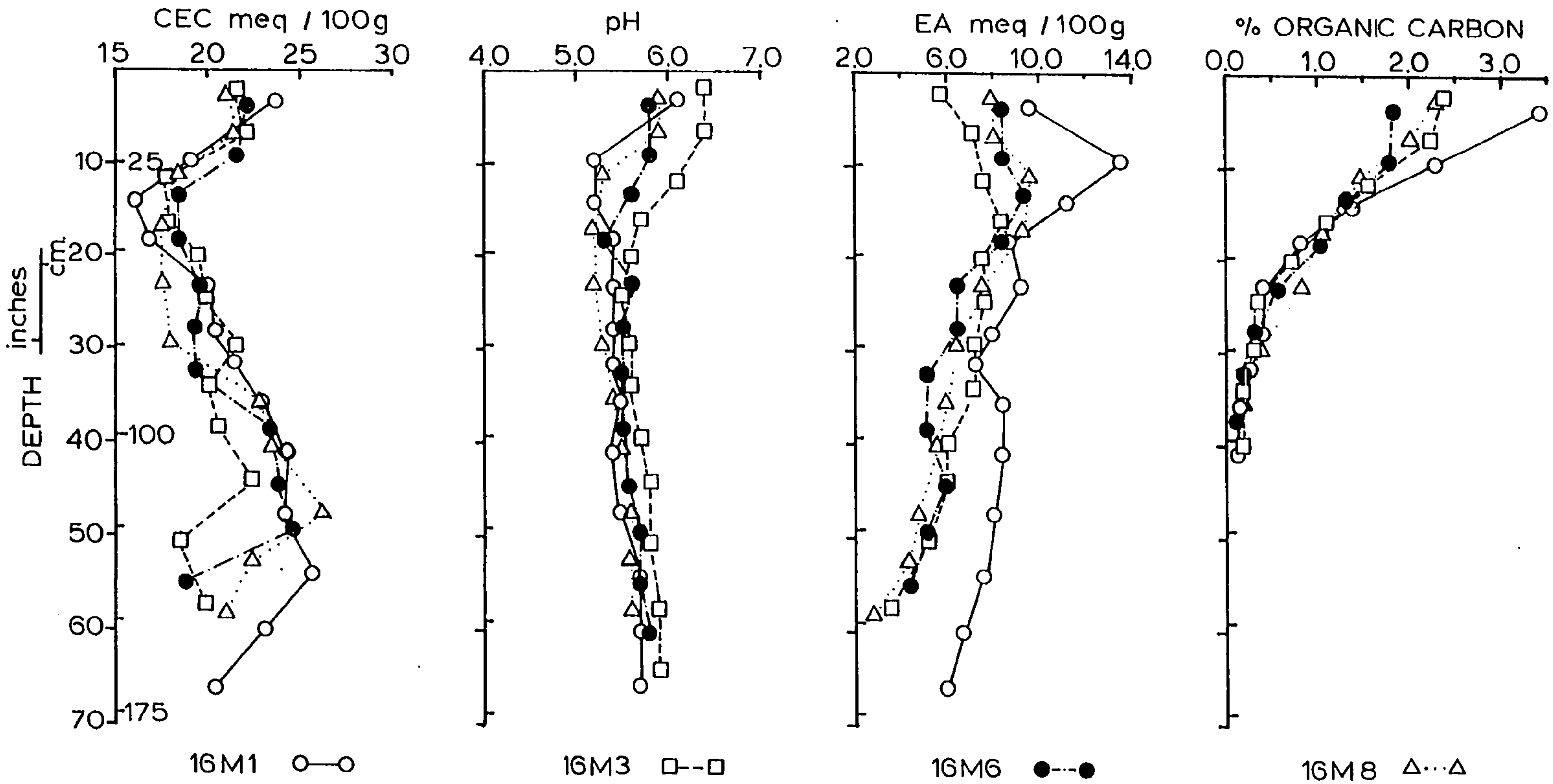


Figure 29. CEC, pH, EA, and OC distribution versus depth for soils of soil group No. 2

the 10 to 40-inch weighted values are less than those weighted results in the 0 to 15-inch zone.

pH The pH distribution for profiles 16-M1, M3, M6, and M8 is plotted in Figure 29. The pH maximum occurs at the surface of each profile within the range of 5.75 to 6.40. The minimum pH values occur at depths of 10 to 25 inches. These minimum values range from 5.20 to 5.50.

Carbonates are leached to depths well below the base of the solum in all four profiles. Therefore, carbonates should have no appreciable effect on solum pH results for these profiles.

Exchangeable acidity The exchangeable acidity distribution for the four profiles is plotted in Figure 29. The EA values reflect a general inverse distribution of the pH values. The maximum EA is within the depth zone of 9 to 20 inches. Profile 16-M1 has a higher overall EA distribution in comparison to the other three profiles. Weighted 0 to 15-inch EA values are 11.2, 7.0, 8.6, and 8.7 meq/100 g. In the 10 to 40-inch depth zone the weighted values are 9.2, 7.4, 6.8, and 6.9 meq/100 g for profiles M1, M3, M6, and M8, respectively.

Organic carbon The percentage of OC for the four profiles is plotted against depth in Figure 29. The depth to 0.58% OC is 20, 22, 21, and 26 inches. The 3.44% OC in the surface horizon of profile 16-M1 is due to the fact that this profile is related to a permanent pasture management system while the remaining three profiles are subject to continuous row-cropping practices.

Characteristics of group No. 3 soils

Morphological characteristics The thickness of the horizon dominated by mollic colors in profiles 16-M5, M18, and M41 is 23, 29, and 22 inches, respectively. Matrix colors in the B horizon are brown (10YR 4/3 and 5/3) and dark yellowish brown (10YR 4/4). The lower B horizon is dominated by yellowish brown (10YR 5/4) colors. Light gray (10YR 7/1) colors are present as ped coatings from 23 to 40 inches in profile M5. Profiles M18 and M41 are generally free of ped coatings. In profiles M18 and M41 subangular blocky structure is predominant from 8 to 36 inches. Below 36 inches fine to medium prismatic structure occurs at a depth of approximately 42 to 45 inches. No prismatic structure was identified in profile M5.

Clay The profile distribution of the percentage of $< 2\ \mu$ is plotted in Figure 30 for profiles 16-M5, M18, and M41. In these profiles the maximum clay is 29.9, 28.0, and 29.5%. These maximum clay contents are lower than those values reported in groups No. 1 and No. 2 soils. The depth to the clay maximum in each profile is 25, 32, and 25 inches. The weighted clay values from 10 to 40 inches are 28.8, 26.4, and 28.3% for profiles 16-M5, M18, and M41, respectively. The B/A clay ratios for the three profiles are 1.21, 1.33, and 1.18. The percentage of clay in profile 16-M18 for sample horizons

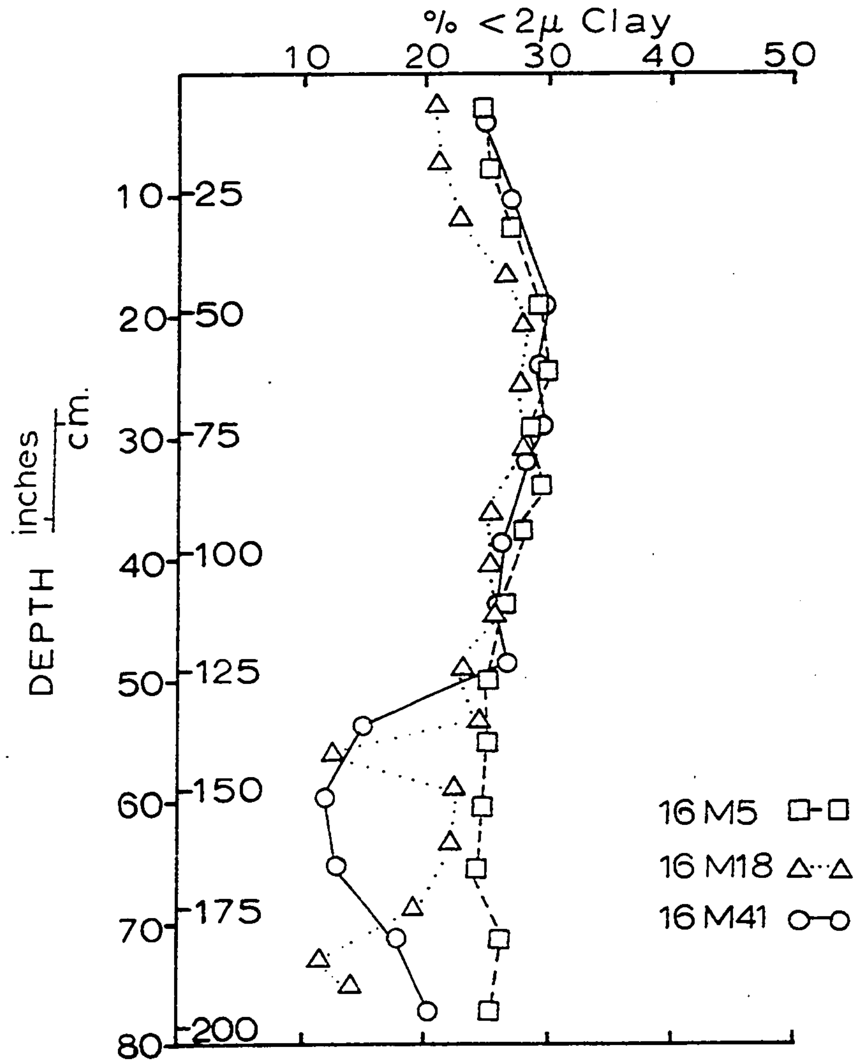


Figure 30. Clay distribution versus depth for soils of soil group No. 3

0 to 5, 5 to 10, and 10 to 14 inches is 21.0, 21.2, and 22.9%, respectively.

Available phosphorus, Bray 1 The available phosphorus distribution for the three profiles is plotted in Figure 31. The minimum AP1 values are 4.5, 7.3, and 3.0 ppm at 19, 26, and 25 inches. The maximum B horizon AP1 values are 35.5, 39.9, and 45.4 ppm. The depth to these maximum AP1 B horizon values if 72, 45, and 49 inches. The 72-inch depth in profile 16-M5 is well below the textural B horizon of the profile.

Cation exchange capacity The CEC distribution for the three profiles is plotted in Figure 32. The minimum CEC values are at depths of 15, 19.5, and 26.5 inches. Weighted CEC values in the 0 to 15-inch zone are 19.1, 19.1, and 16.9 meq/100 g. These values are 4.0 to 6.0 meq/100 g lower than values determined in Tama soils. Weighted CEC values for the 10 to 40-inch zone are 19.3, 18.9, and 17.7 meq/100 g.

pH The pH distribution for these profiles is plotted in Figure 32. Profiles 16-M18 and M41 approach pH 7.0 in the surface horizons. The minimum pH zone for all three profiles is between 33 and 36 inches. This depth is well below the depth to pH minimum in group No. 1 soils (15 to 35 inches) and group No. 2 soils (10 to 25 inches), yet the pH values, 5.3, 5.5, and 5.65, are within the range of the other soil groups. In both profiles 16-M18 and M41 the depth to underlying sand zones is within 2.0 feet of the base of the solum.

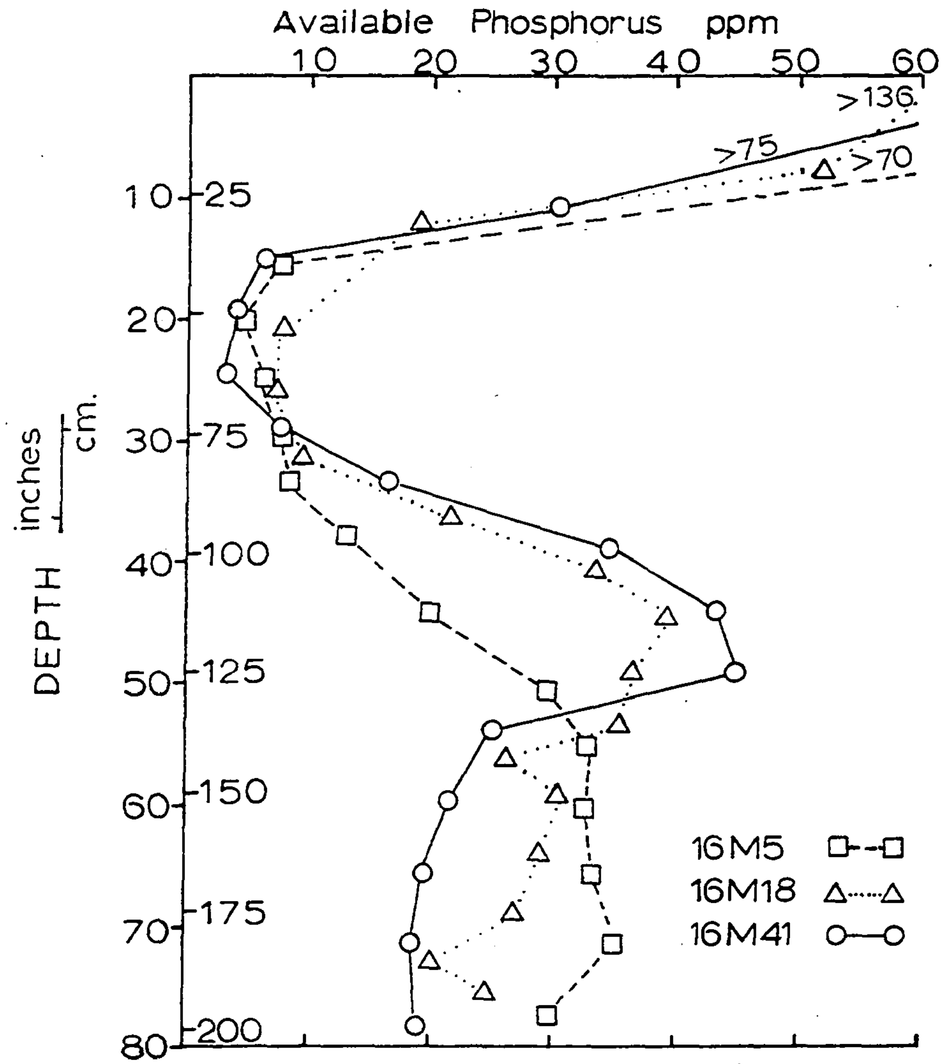


Figure 31. APl distribution versus depth for soils of soil group No. 3

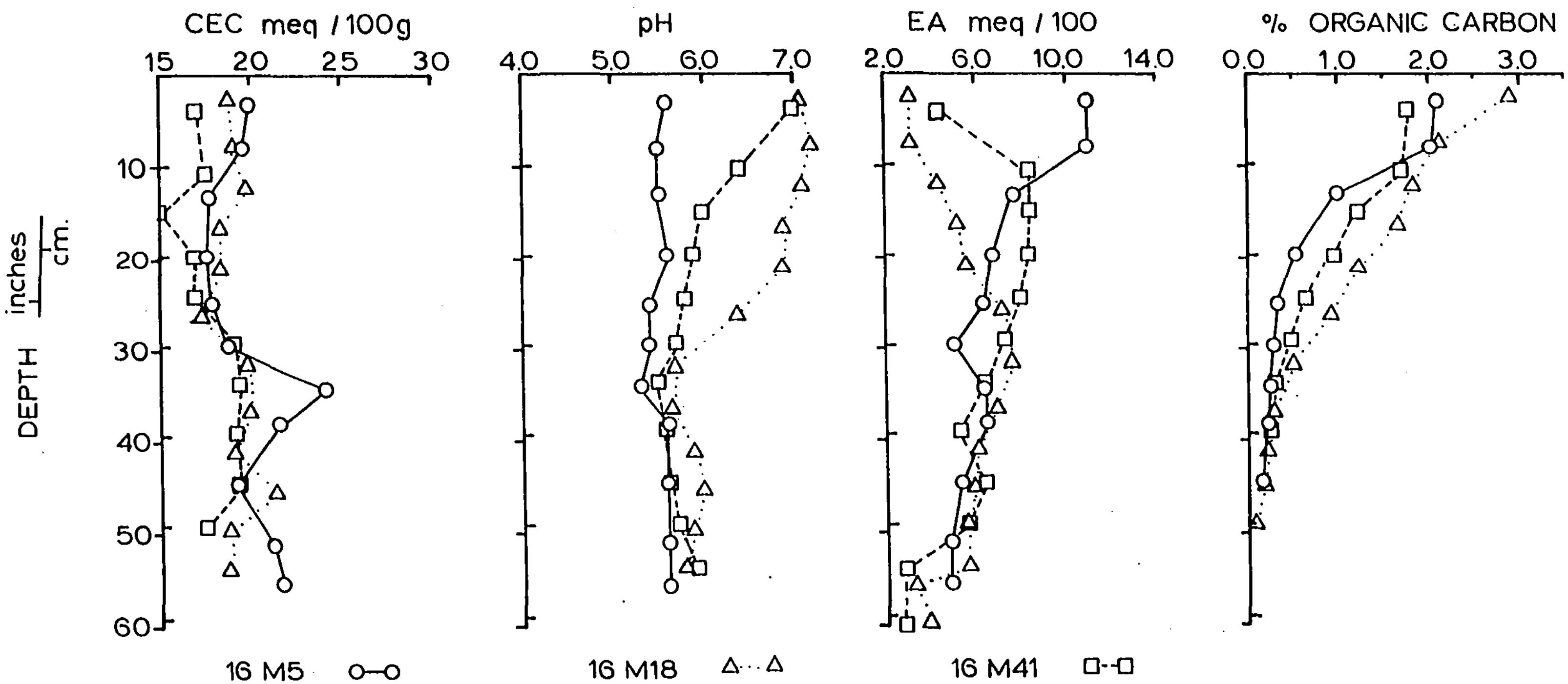


Figure 32. CEC, pH, EA, and OC distribution versus depth for soils of soil group No. 3

Exchangeable acidity   The exchangeable acidity distribution for profiles 16-M5, M18, and M41 is plotted in Figure 32. Exchangeable acidity, to a depth of 20 inches for the composite profiles, has a wide range of values. This difference was noted in the plot of pH distribution for the same set of profiles. Weighted EA values for the 10 to 40-inch zone are 6.5, 6.2, and 7.4 meq/100 g.

Organic carbon   The percentage of organic carbon for the three profiles is plotted in Figure 32. The depth to 0.58% organic carbon is 16, 29, and 27 inches. All three profile sites are currently in continuous cropping practices. No evidence is available to indicate that management practices have been different in the past. The organic carbon distribution in profile 16-M5 is similar to that found in the group No. 1 soils. However, the thickness of the mollic epipedon in profiles 16-M18 and M41 is greater than group No. 1 soils on 1 to 2% slopes. Interior ped colors of dark brown (10YR 3/3) occur at depths of 19 to 29 and 17 to 27 inches, respectively. There are no physical features observable which suggest that these high levels of organic carbon are present in either of the two profiles.

Soils of the Bennett transect

The Bennett transect is composed of prairie-derived and transitional soils. The transect includes the well drained to poorly drained members of the drainage sequence.

This transect of soils consists of two parts: (1) the transect across the thick loess-mantled Iowan surface and (2) the transect along the south flank of the Bennett paha.

The portion of the transect across the Iowan surface consists of soils formed on thick loess superjacent to sands or truncated till. The occurrence of sands beneath the loess body and above the truncated till surface are limited to those geographic areas of the primary divide which are now expressed as swells or convex highs at the ground surface of the landscape.

In the field, the southern portion of the transect traverses a north and northeast facing slope which has a maximum gradient of 2%. Soil profiles 16-M7B through 16-M7K are located 100 feet apart along the transect. Profile M7A is 340 feet southwest of profile M7B. The drainage class designation and associated stratigraphic information for each profile is listed in Table 11.

The portion of the transect along the south flank of the Bennett paha consists of soils formed on thick loess across the backslope of the paha. This part of the transect traverses 300 feet along a gradient of 6 to 8%. Soil profiles 16-M26 through 16-M30 are located on this part of the transect.

The well, somewhat poorly, and poorly drained soils are represented by profiles 16-M7B, M7E, and M7I. These profiles are located on the transect extending across the Iowan surface. Solum properties such as clay, available phosphorus, OC, pH, CEC, and EA are plotted in Figures 33, 34, and 35 for these soils.

The clay maximum (Figure 33) increases in percentage across the landscape from the well to poorly drained soils as well as decreases in solum depth in the same drainage sequence. Weighted clay values for the 10 to 40-inch zone are 29.9, 31.3, and 32.7%. The depth to the maximum clay values are 21, 21, and 15 inches. The B/A clay ratios are 1.20, 1.34, and 1.22.

The available phosphorus, AP1, increases from the well drained soil to the somewhat poorly drained soil. The decrease in AP1 in the poorly drained soil is related to the pH values above 7.0 at depths below 30 inches (Figure 33).

The higher concentration of HCl in the AP2 extraction procedure results in the release of phosphorus from calcium phosphates. Figure 35 shows the distribution of the AP2 for the soils of the toposequence. A large quantity of AP2 is present in the B horizon of the poorly drained soil. In the well and somewhat poorly drained soils the minimum AP2 values are in the same sample horizon as the minimum AP1 values (Figures 33 and 35).

The organic carbon distribution (Figure 33) in the somewhat poorly drained soils is less than either the well or poorly drained counterparts. The well drained soil has OC values greater than 0.58% to a depth of 24 inches. The somewhat poorly drained soil has less than 0.58% OC below a depth of 12 inches.

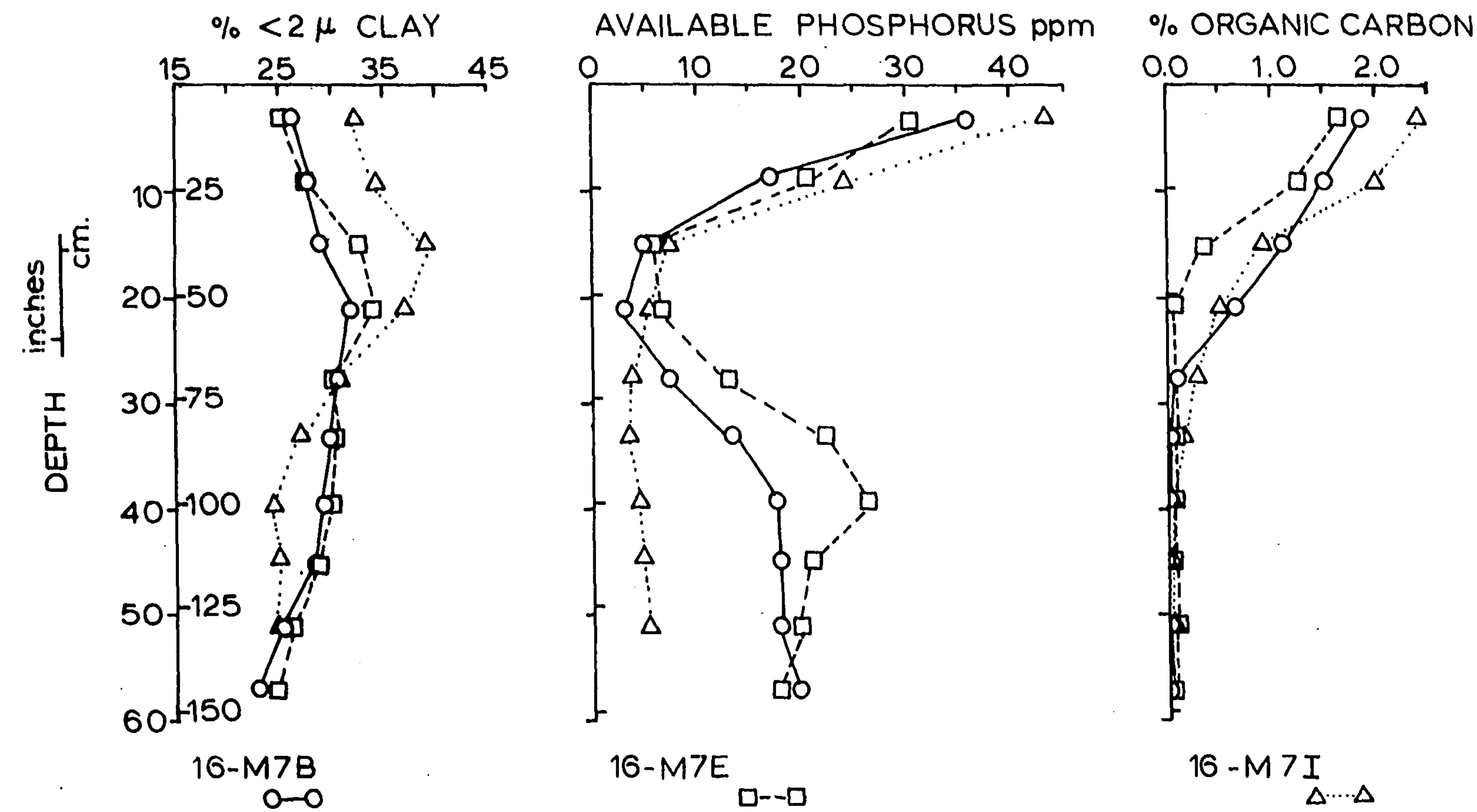


Figure 33. Clay, APl, and OC distribution versus depth for well, somewhat poorly, and poorly drained soils of the Bennett transect

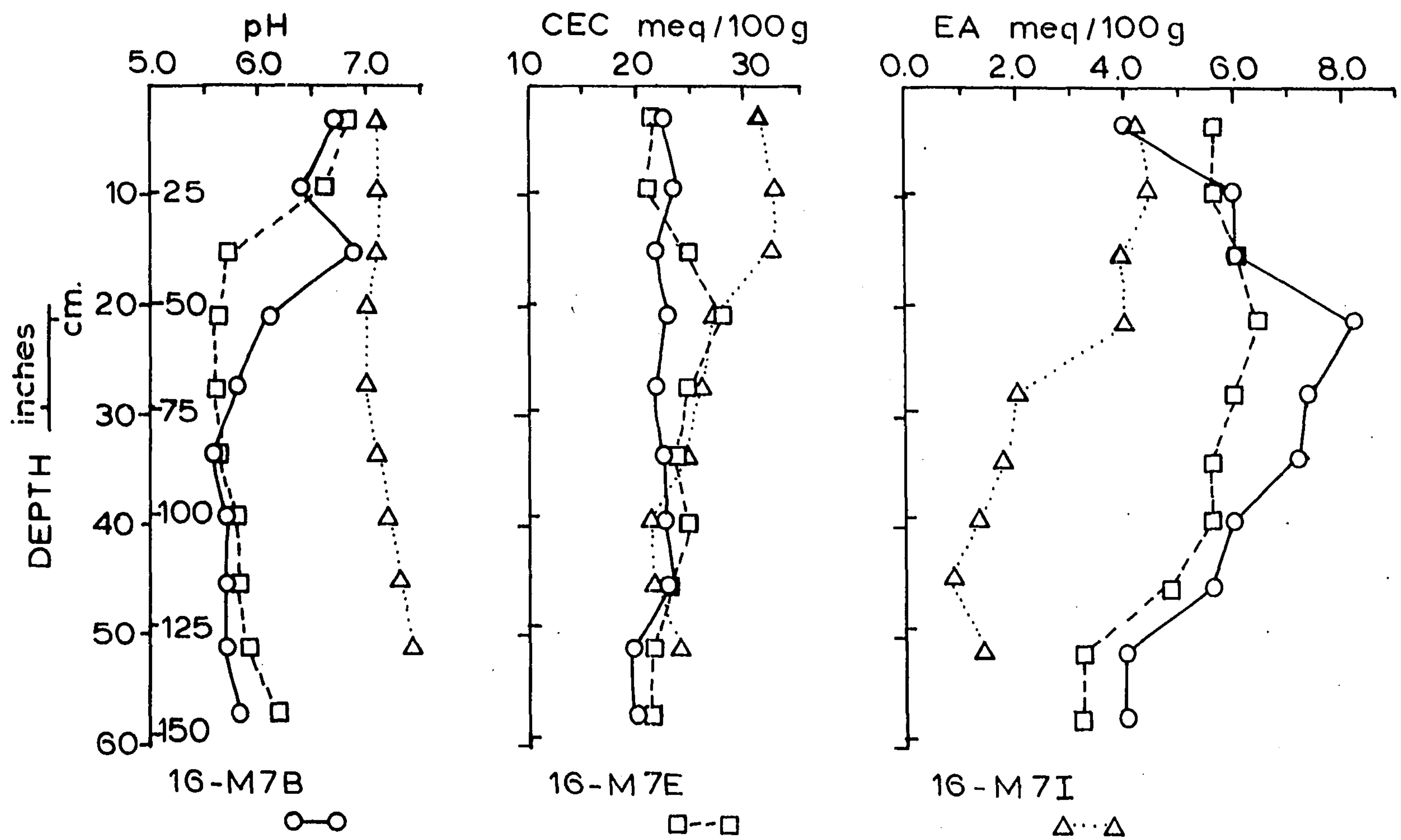


Figure 34. pH, CEC, and EA distribution versus depth for well, somewhat poorly, and poorly drained soils of the Bennett transect

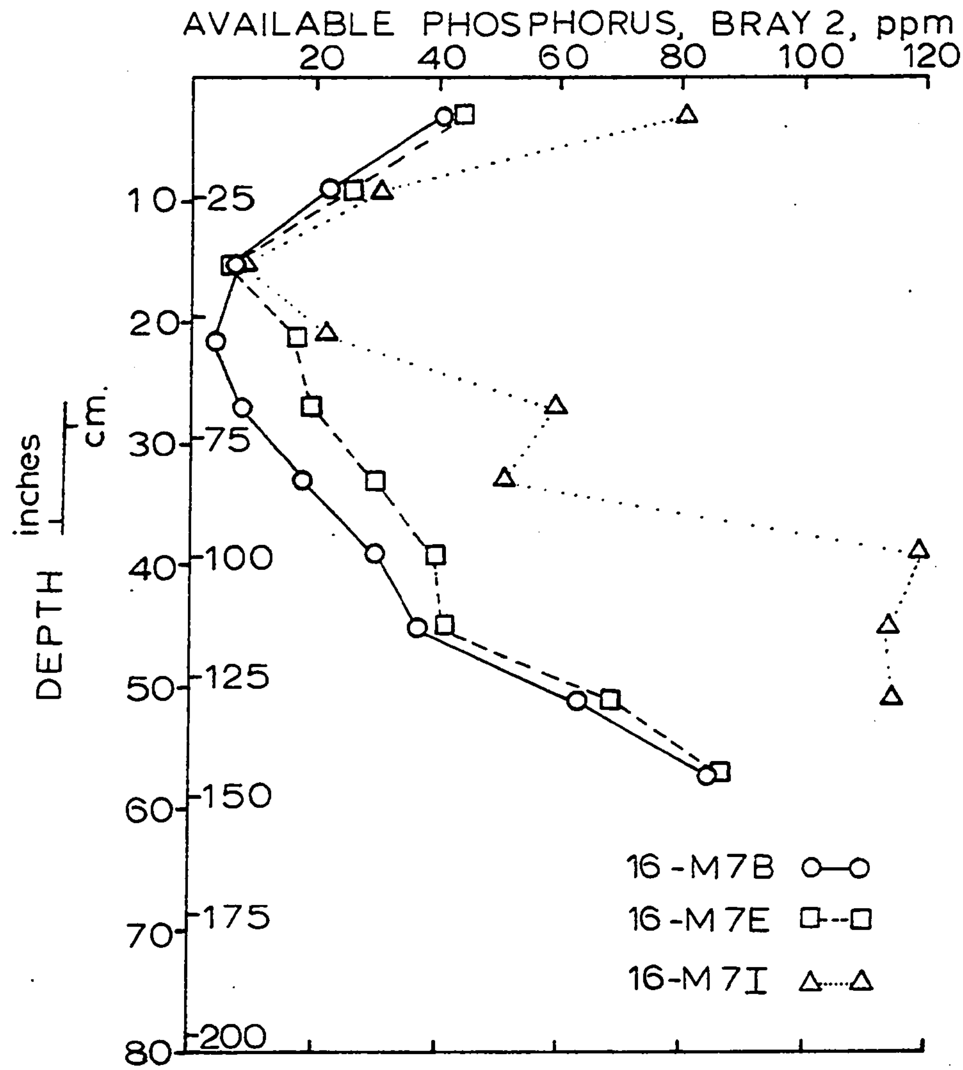


Figure 35. AP2 distribution versus depth for well, somewhat poorly, and poorly drained soils of the Bennett paha

The depths to the minimum pH values (Figure 34) are 33, 21, and 21 inches. The minimum pH values are 5.6, 5.6, and 7.0 for these soils. Weighted pH values for the 10 to 40-inch zone of these soils are 6.06, 5.71, and 7.07.

The cation exchange capacity for the soils of the hydro-toposequence is plotted in Figure 34. The maximum value in each solum increases from the well drained to poorly drained drainage class, and in the same order decreases in profile depth. Weighted CEC values for the 10 to 40-inch zone are 22.3, 24.8, and 27.2 meq/100 g.

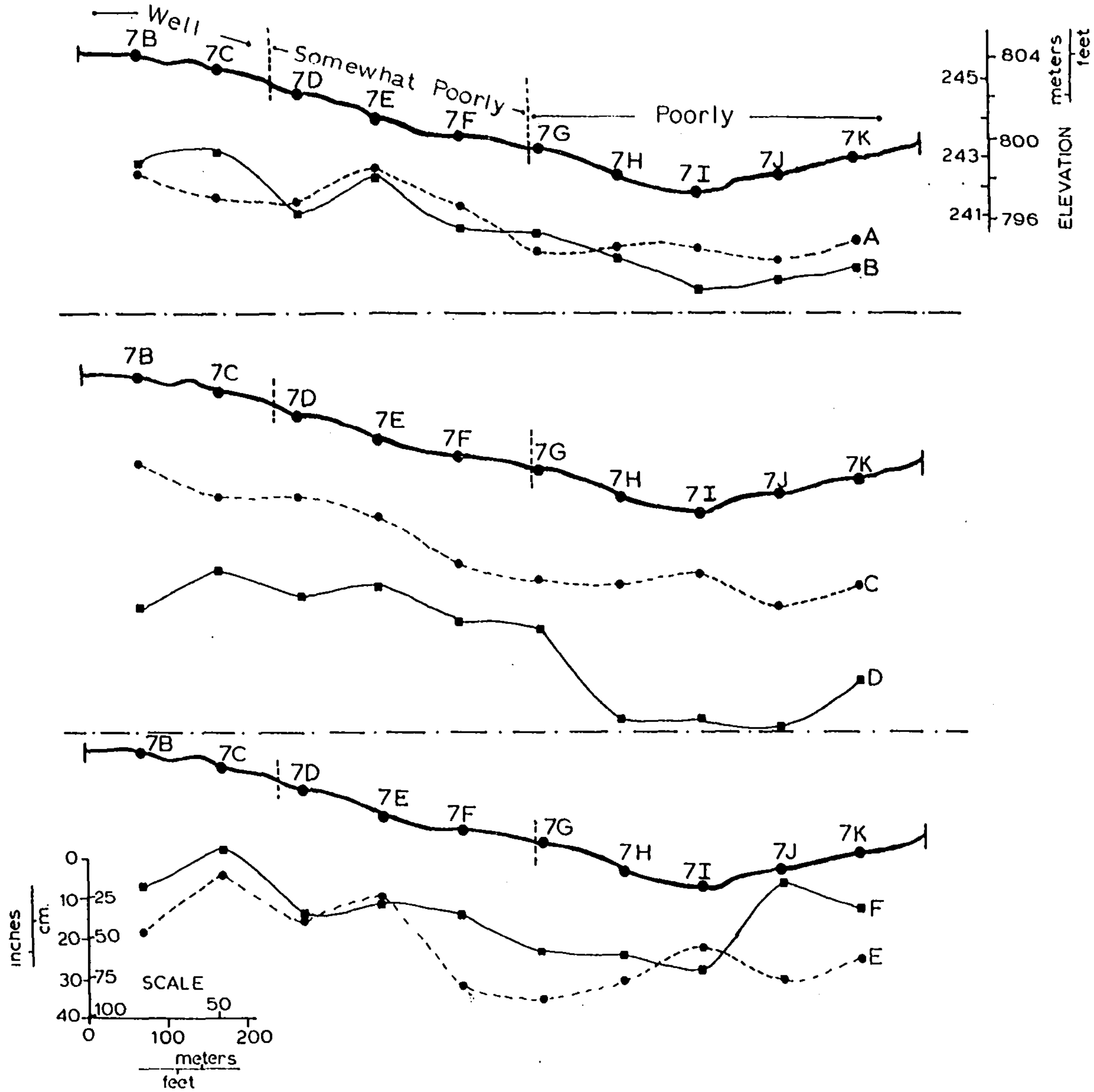
The exchangeable acidity distribution in the three profiles is inverse of the pH distribution in each profile (Figure 34). Weighted EA values for the 10 to 40-inch zone are 7.4, 5.9, and 2.9 meq/100 g.

Univalued profile characteristics compiled for all 10 profiles of the transect provides evidence of changes which occur in the hydro-toposequence as the slope and drainage class change across the landscape. Univalued properties for six physical and chemical properties are plotted for all 10 profiles in Figure 36.

The univalued results (Figure 36) indicate that the depth to gray mottles is least along the somewhat poorly drained portion of the hillslope. Cumulic material is present at the sites of profiles 7H through 7K. The presence of this material may be responsible for the increased depth to gray mottles at these four profile sites.

Figure 36. Plot of univalued properties for soils of the Bennett transect

A. Depth to gray mottles
B. Depth to < 0.5% OC content
C. Depth to maximum clay content
D. Depth to maximum APl value in subsoil
E. Depth to maximum CEC value in subsoil
F. Depth to minimum pH value below ground surface


Well
Somewhat Poorly
Poorly
7B
7C
7D
7E
7F
7G
7H
7I
7J
7K
A
B
C
D
E
F
245
243
241
804
800
796
meters
feet
ELEVATION
0
10
20
30
40
25
50
75
100
inches
cm.
SCALE
50
0
100
200
meters
feet

The vertical distribution of OC accumulation above 0.5% increases in thickness at the footslope and toeslope components of the hillslope (Figure 36). The shallow depth to less than 0.5% OC at profile 7E does not fit within the hillslope pattern. The weighted OC value for the 0 to 15-inch zone is 1.22%. This value is lower than any other weighted surface OC content in this transect (Table 12). Also, the B horizon of profile 7E is characterized by a matrix color of dark grayish brown (2.5Y 5/2) below 13 inches.

The depth to clay maximum (Figure 36) decreases slightly in the area of the somewhat poorly drained soils. The decrease in depth to clay maximum in profile 7D is also associated with a decrease in maximum percentage of clay (Table 12). The maximum clay content increases across the hillslope from the well drained members to the poorly drained members (Table 12).

The distribution of AP1 (Figure 36) shows the effect of high pH values on the quantity of available phosphorus present. The increased depth to maximum AP1 values in the poorly drained soils (Figure 36) is accompanied by a marked decrease in the quantity of AP (Table 12). A comparison of the increased pH values and decreased AP1 values, expressed as weighted values over the 10 to 40-inch zone, in Table 12 demonstrates the concepts of Ca-phosphate availability and pH which were reviewed in the background section. This increase in pH values is accompanied by a decrease in the depth to maximum pH values below the surface horizon

Table 12. Some profile characteristics for the soils of the Bennett transect

Property		Profile number			
		M7A	M7B	M7C	M7D
1.	Depth to clay maximum	21	21	27	21
2.	% clay max.	29.8	31.6	31.2	29.4
3.	Weighted % clay; 10-40"	29.3	29.9	29.6	28.6
4.	B/A ratio	1.17	1.20	1.32	1.15
5.	Max AP1 (ppm) in subsoil	19.2	19.5	25.3	27.7
6.	Depth to AP1 max., inches	43	57	39	45
7.	Weighted pH; 10-40"	5.9	6.1	5.7	5.8
8.	Weighted EA; 10-40"	6.6	7.4	7.6	6.8
9.	Max. CEC; meq/100 g	22.9	22.9	22.5	21.6
10.	Weighted CEC; 10-40"	22.4	22.3	20.3	20.2
11.	Weighted OC; 0-15"	1.94	1.58	1.51	1.60

Profile number						
M7E	M7F	M7G	M7H	M7I	M7J	M7K
21	27	27	21	15	27	27
33.7	31.5	32.1	35.1	39.3	35.4	39.7
31.3	29.4	30.1	32.6	32.7	31.3	34.3
1.34	1.29	1.23	1.26	1.22	1.25	1.65
26.5	28.4	24.9	30.8	5.1	4.6	3.0
39	39	39	54	51	57	51
5.7	5.8	5.8	6.6	7.1	7.1	6.6
5.9	6.0	6.4	5.2	2.9	3.8	4.8
27.7	29.5	26.3	31.1	32.4	32.3	36.6
24.8	21.6	22.4	29.4	27.2	31.3	33.6
1.22	1.72	1.68	1.65	1.98	2.32	2.07

(Figure 36).

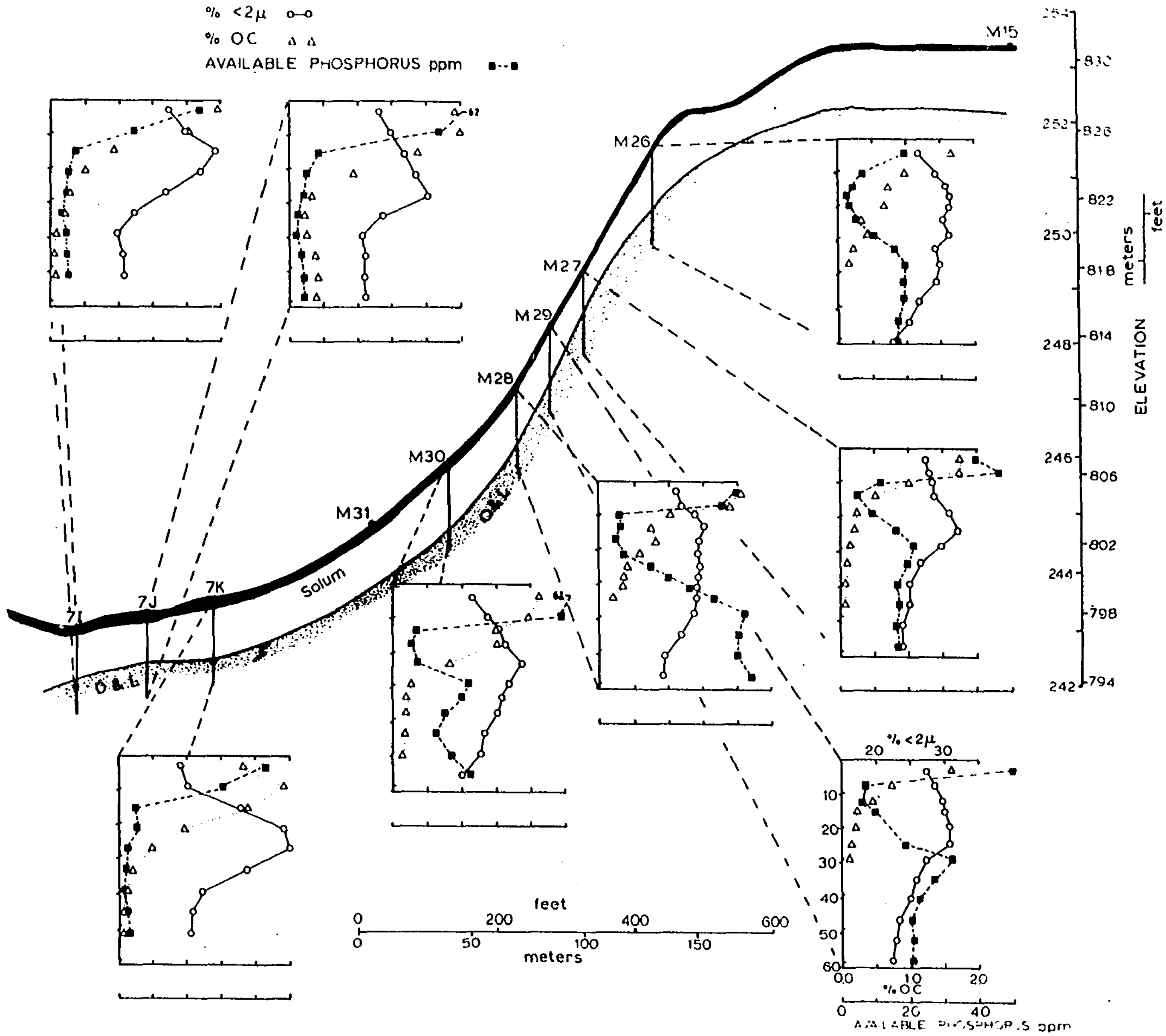
The depth to the maximum CEC value across the hillslope is plotted in Figure 36. In profiles 7C and 7E the CEC maximum is in the same sample horizon as the maximum clay content. In profiles 7B, 7D, 7F, and 7G the maximum CEC values are at a greater depth than the maximum clay content. In profiles 7H through 7K the depth to the maximum CEC values are within the same sample horizon as the maximum clay content or within 6 inches above or below the maximum clay zone.

Solum characteristics are plotted in Figure 37 for the moderately sloping well drained soils located on the south-facing flank of the Bennett paha. This plot includes the percentage < 2 µ clay, organic carbon, and APl.

The percentage of clay decreases in quantity and depth from a maximum amount at the shoulder to a minimum at the base of the backslope. An increase in quantity occurs in the upper footslope component. Down slope, from profile M26 to M30, the depths to clay maximum in each profile are 28, 24, 24, 13, and 23 inches. The corresponding percentages of clay are 31.4, 32.2, 30.9, 30.3, and 33.7. The B/A ratios, in the same profile order, are 1.17, 1.17, 1.12, 1.15, and 1.27.

The organic carbon distribution in each succeeding profile down the hillslope reflects the results of removal and accretion (Figure 37). The weighted organic carbon percentage in the 0 to 15-inch zone from profile M26 to M30 is 1.30, 1.27, 0.97, 1.48, and 1.92. In profile 16-M7K the weighted

Figure 37. Location of soil profiles in relation to hillslope position along the south flank of the Bennett paha. Clay, OC, and API distribution versus depth for profiles 16-M26 through 16-M30 and 16-M7I through 16-M7K



% <2μ
% OC
AVAILABLE PHOSPHORUS ppm
M15
M26
M27
M29
M28
M30
M31
7I
7J
7K
Solum
feet
0
200
400
600
0
50
100
150
meters
ELEVATION
meters
feet
254
252
250
248
246
244
242
830
826
822
818
814
810
806
802
798
794
% <2μ
20
30
10
20
30
40
50
60
0.0
1.0
2.0
% OC
0
20
40

percentage is 2.07.

The AP1 distribution for each profile is also included in Figure 37. The maximum AP1 values in the B horizon, from profile M26 to M30, are 21.0, 22.0, 32.8, 44.3, and 22.5 ppm. Profile M28, located at the base of the backslope, has the greatest quantity of AP1 in the B horizon. Weighted AP1 values for the 10 to 40-inch zone in profiles M26 to M30 are 10.1, 14.6, 20.2, 7.1, and 13.9 ppm. Profile M28 has the lowest weighted value. The weighted AP1 values for the 10 to 60-inch zone are 13.5, 17.3, 20.5, 21.0, and 15.3 ppm. Profile M28 has the greatest weighted value in this analysis. Downslope, on the footslope, profiles M7I, M7J, and M7K have a minimum amount of AP1 in the B horizon.

DISCUSSION

The discussion section is organized similar to the results section. Topics are discussed from the bottom up, stratigraphically, beginning with the buried bedrock surfaces and ending with a discussion of the ground soils.

In this section each major topic is introduced by means of a short resume of the results acquired in either the field or laboratory. Each resume is followed by an interpretation and discussion of the facts and evidence. At the termination of each major subject such as bedrock surfaces, weathering zones, and ground soils, for example, conclusions for the respective topic are presented.

Thickness of Quaternary Deposits

The results of the thickness distribution of unconsolidated materials are shown in Figure 8. These results show that (1) bedrock highs on the bedrock paleosurface are subjacent to the broad stable upland summits on the modern surface, and (2) the least vertical thickness of unconsolidated sediments commonly occurs between the paleosurface of the bedrock high and the broad upland flats of the modern surface which form the primary divide of major river valleys.

Field studies in southwestern Iowa during the past 25 years have shown that the thickest loess deposits form the core of the upland interfluves (Ruhe et al., 1967). In other areas of the state the thickest loess deposits may or may not form the core of the upland interfluves (Kay and Apfel, 1929, p. 58). The relationship between total thickness of the unconsolidated sediments and the location of the primary divides have not been studied to the same degree of detail.

Recent studies of the bedrock surfaces and related landscape topography from the Nishnabotna watershed in western Iowa indicate that the Quaternary deposits with the least vertical thickness may be at the base of the upland divides (Stone, 1970, p. 16-24). Similar evidence is available from study of the broad tabular flats of south-central Iowa. In southern Wayne County the unconsolidated sediments are the thinnest at the topographic divide between tributaries of the Chariton and Weldon Rivers (Iowa Geological Survey, 1973, p. 23).

This problem can be studied for other areas of the state in the future. The recent publication of several bedrock isopach maps (Hansen, 1972, 1973; Cagle, 1973) will readily assist the investigator.

The evidence that the broad stable upland divides may be underlain by the thinner deposits of unconsolidated sediments provides a new dimension in Quaternary studies. This evidence could provide for: (1) a better understanding of the lateral extent and areal distribution of pre-Wisconsinan till units; (2) an explanation for the evolution of the level interfluvial divides (Shrader and Hussey, 1953) across southern Iowa; and

(3) a better understanding of the local and regional distribution of groundwater gradients in unconsolidated deposits.

In the area studied there is no evidence that more than one till unit is present. Perhaps early till deposits were removed from this upland divide by subsequent glaciation as has been suggested for other parts of the state (Kay and Apfel, 1929, p. 135). Review of unpublished well logs[1] provides no evidence of more than one till unit along the Cedar-Wapsipinicon River divide either under the thick loess-mantled Iowan surface or the Yarmouth-Sangamon surface.

Parent Material Models

Areal stratigraphy

On the northern end of the reconnaissance traverse coreholes 16-M18, M23, and M41 confirm the presence of the Iowan erosion surface complex. These coreholes reveal that (1) the loess thickness on this surface may range from 2.5 feet, corehole M23, up to 6 or more feet, corehole M18; (2) sands may overlie the truncated till surface, coreholes M18 and M41; and (3) the depth to underlying bedrock may be within 8 feet of the ground surface, corehole M41.

The coreholes to the south of corehole 16-M18 (Figure 2), from coreholes 16-M11 and M20 to 16-M9 and 82-M1, reveal that

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[1]Iowa Geological Survey. Printout of stratigraphy and depth data for 149 well logs, Cedar County, Iowa. Iowa City, Iowa. 1972.

much of the area parallel to the Cedar-Wapsipinicon River divide consists of a thick mantle of loess over truncated till. The identification of a thick loess-mantled Iowan erosion surface along this upland divide is evidence for an erosional artery between the previously defined Iowan erosion surface (Ruhe et al., 1968) and the Cleona channel. Ruhe (1968a) and Ruhe and Prior (1970) have demonstrated that coarse sediments fill the base of the Cleona channel as well as the "Lake Calvin" basin to the southwest.

The evidence to substantiate this extension of the Iowan erosion surface is the same as found by Ruhe and his associates in Tama, Grundy, and Linn counties (Ruhe et al., 1968). Stratigraphic features are: (1) no paleosols between the loess and till, (2) increments of sand between the loess and till on the Iowan surface, (3) intercalated sands in the flanks of paha, (4) leached zones in the subjacent till grading to unleached zones, (5) an increase in loess thickness from the Iowan surface to paha and inliers, and (5) no unoxidized weathering zones in loess on the Iowan surface. The topographic features include: (1) little to no stream dissection encroaching onto upland flats and the presence of closed depressions are common, (2) descendance of undulating and gently rolling slopes to a regional drainage net, (3) the presence of paha and inliers, and (4) lower absolute elevation of the Iowan surface where it abuts surfaces controlled by the Yarmouth-Sangamon paleosol (YSP).

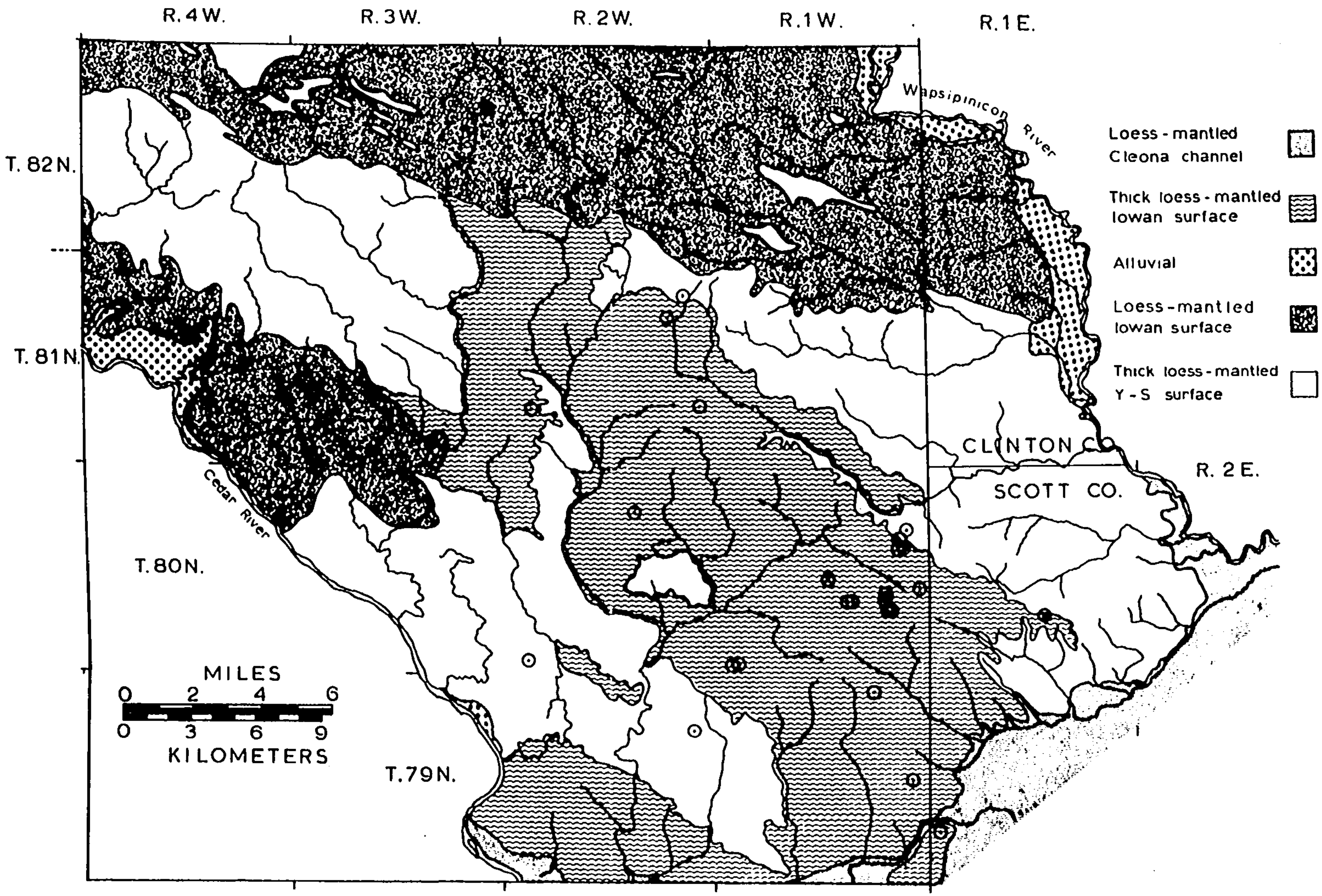
The actual areal extent of the thick loess-mantled Iowan surface can be defined on the basis of coreholes, topographic map interpretation, and soil maps. This information is used to construct a map delineating the areal distribution of the thick loess-mantled Iowan erosion surface (Figure 38).

The thick loess-mantled Iowan surface area differs from the loess-mantled Iowan surface area on the basis of loess thickness. The thick loess-mantled Iowan area has a loess thickness of 9 to 18 feet on the stable interfluves. In the loess-mantled Iowan area the loess thickness is less than 7 feet.

In this investigation 20 coreholes provided the detailed stratigraphic information for defining the extent of the thick loess-mantled Iowan surface. Coreholes 16-M15, M19, M22, and M24 are representative of thick loess, 23 to 27 feet, over a Yarmouth-Sangamon paleosol. Coreholes 16-M15 and M19 are on paha. Coreholes 16-M22 and M24 are from the Kansan drift area. The other 16 coreholes (Figure 2) consist of 9 to 18 feet of loess over truncated till. A comparison of the weathering zones and $< 2\ \mu$ clay from the surface of the truncated till downward is shown for three of these cores in Figure 39. A total of 11 of the 16 coreholes contained aeolian sands between the loess and till. These sand deposits ranged in thickness from a few inches, corehole 16-M14, to 8.5 feet, corehole 16-M11.

In addition to the subsurface stratigraphy the nature of

Figure 38. Areal distribution of loess-mantled surfaces for study area in eastern Iowa


R.4W.
R.3W.
R.2W.
R.1W.
R.1E.
R.2E.
T.82N.
T.81N.
T.80N.
T.79N.
Wapsipinicon River
Cedar River
CLINTON C
SCOTT CO.
MILES
0 2 4 6
0 3 6 9
KILOMETERS
Loess-mantled Cleona channel
Thick loess-mantled Iowan surface
Alluvial
Loess-mantled Iowan surface
Thick loess-mantled Y-S surface

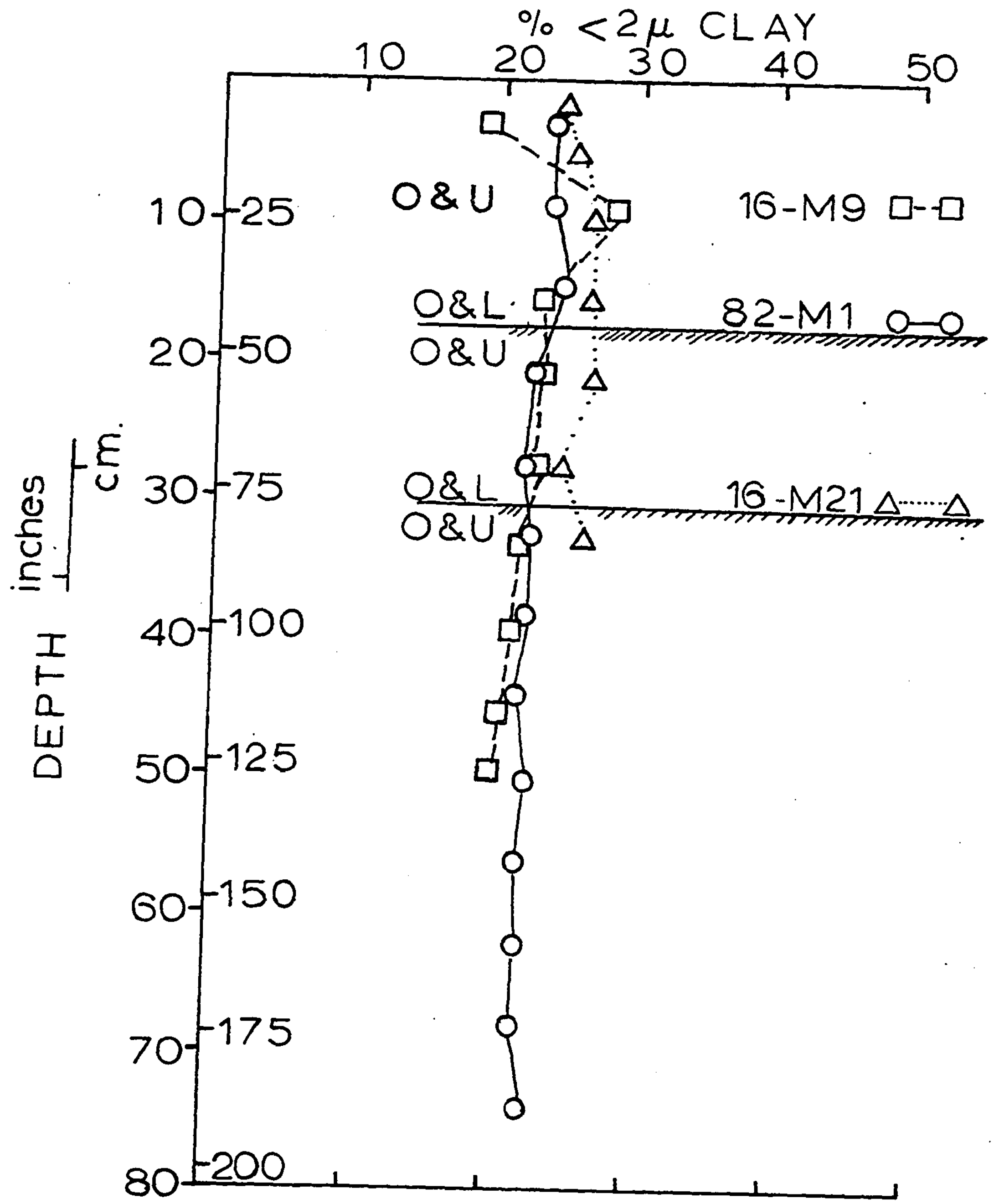


Figure 39. Clay distribution versus depth in weathering zones of till for coreholes 16-M9, 16-M21, and 82-M1

the landscape topography was studied on $7\frac{1}{2}$ minute quadrangle maps. Soil maps were studied in association with these topographic maps. The soil maps were used to define and identify ground soils associated with and formed on exhumed paleosols. The results of this investigation provides for the delineation of approximately 105,000 acres of land surface in Cedar and Scott counties which can be classified as thick loess-mantled Iowan erosion surface (Figure 38).

<u>Thick loess-mantled surfaces</u>

In the Bennett transect corehole observations of the thick loess-mantled Yarmouth-Sangamon surface (YSS) are represented by 16-M15, M26, M27, and M29. Corehole 16-M28 represents an observation of the erosional interface between the south flank of the paha and the thick loess-mantled Iowan surface. The remainder of the cores to the south of corehole 16-M28 are observations representing the Iowan surface (Figure 17).

The stratigraphic aspects of this transect reveal that: (1) an erosional surface cut across weathering zones in Wisconsinan loess, stripped the YSP, and cut through the leached zone into the unleached zone of the subjacent till; (2) the coarse sands remaining as a lag on the eroded surface were shifted by eolian processes and piled into dune-like features on the truncated surface as well as being blown upslope onto the loess covered paleosurfaces of the paha; (3) the erosion surface was stabilized by loess deposits that covered the entire landscape with a fairly uniform thickness; which (4) resulted in a loess thickness differential between the Yarmouth-Sangamon and the Iowan surfaces.

The evidence for these interpretations occur in the material present in the coreholes (Figure 17). In coreholes 16-M15, M26, M27, and M29 a YSP is present. In corehole 16-M28 the YSP has been truncated below the B horizon and probably to the lower B3 horizon of the paleosolum. As reported in a previous section, Figure 17 shows an elevation difference of 11.4 feet between the paleosurface of the YSP in 16-M29 and M28. The physical properties of the material below the loess-YSP or TYSP interface are shown in Figure 40. In this illustration the percentage of $< 2\ \mu$ clay is plotted against depth from the paleosurface downward for the YSP in coreholes M15 and M29, and the TYSP in corehole M28. Therefore, south of corehole 16-M29 at least 11.0 feet or more of the paleosolum and till have been stripped from the paleosurface.

In coreholes 16-M31, M7I, M32, and M7A, which occur on the thick loess-mantled Iowan surface, the till subjacent to the calcareous loess or sands is leached (Figure 17). Two interpretations can be formulated from this evidence. First, this leached zone may represent the leached portion of a relict paleosol or the leached material subjacent to the relict paleosol. This relict paleosol would have been present prior to the cutting of the Iowan surface. Second, the leached zone

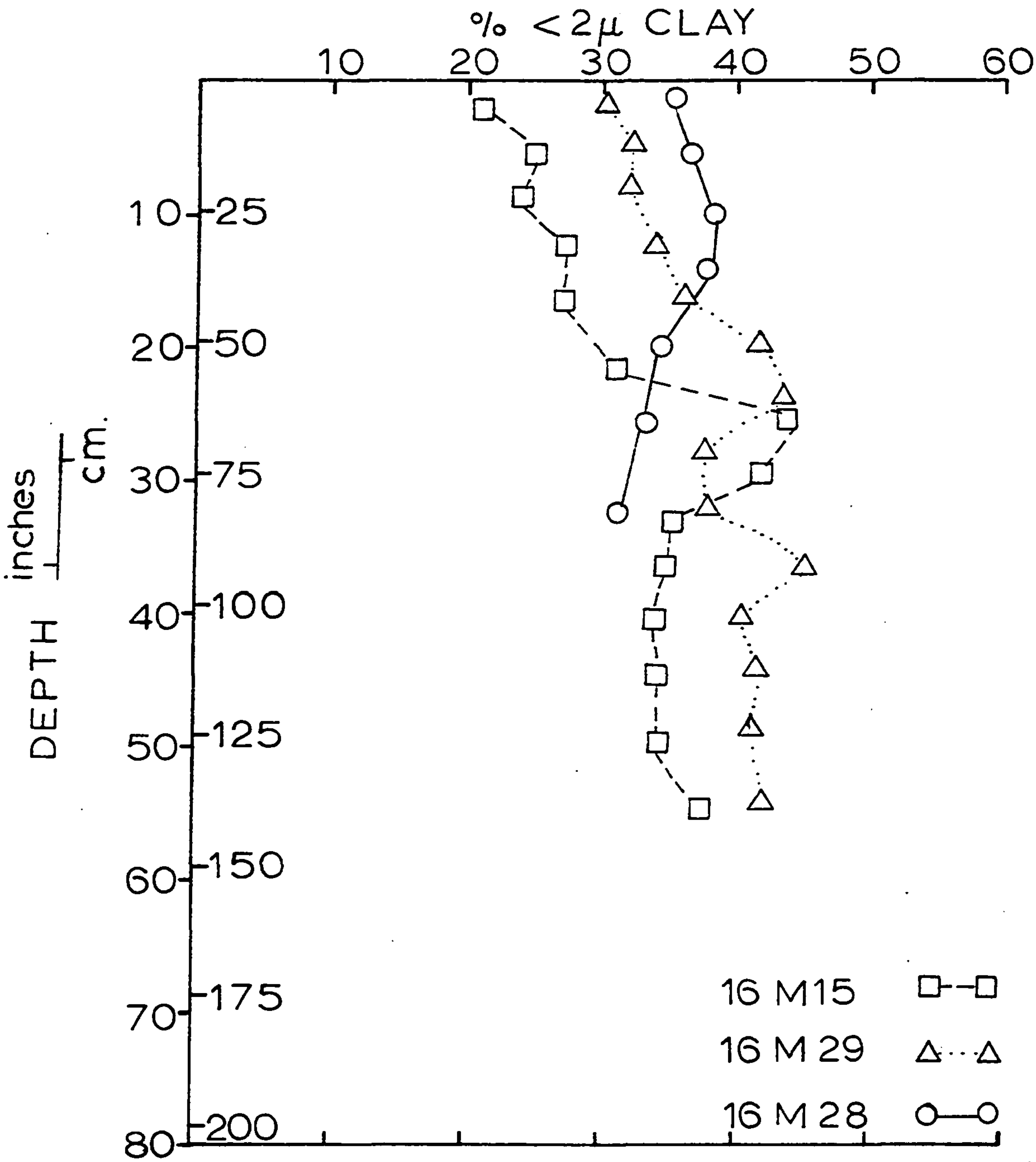


Figure 40. Clay distribution versus depth for paleosols from the Bennett paha

in the till may be a result of leaching which occurred concurrent or subsequent to the erosion of the till surface, but prior to the deposition of calcareous loess. There is no evidence of incipient soil formation in the upper leached till. Therefore, the first hypothesis is probably correct. Hall (1965, p. 81a) observed similar relationships in the Salt Creek area of Tama County, Iowa.

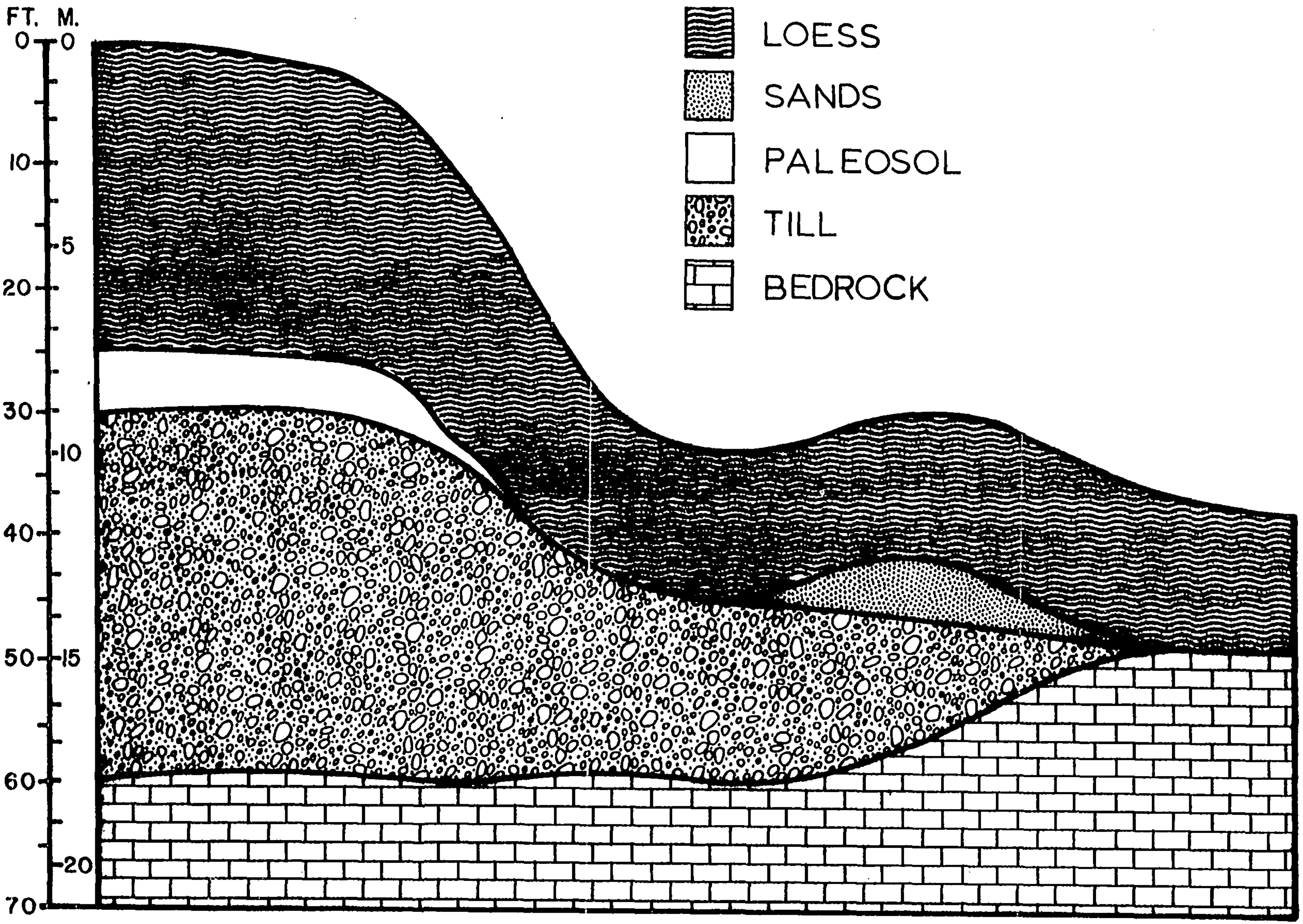
In coreholes 16-M30, M32, and M7A sands occur between the loess and truncated till. The superjacent loess blanket is relatively sand free. On the south flank of the Bennett paha coreholes 16-M26, M27, M28, and M29 contain lens and strata of intercalated silts and sands within the loess deposit (Figure 17). These intercalated sands in the flank of the paha must have been deposited by aeolian processes as they occur above the erosional unconformity which cuts across the deoxidized and unoxidized weathering zones in the loess. These lens and strata of sand indicate that the sand was blown from the adjacent erosion surface up onto the flank of the paha to form an on-lap/off-lap phase of hillslope construction and slope removal.

The sands remaining on the truncated Iowan erosion surface apparently were concentrated into dune-like features by the wind. The remnants of these sand dunes may be located by observing the modern surface. On the thick loess-mantled Iowan surface extending along the Cedar-Wapsipinicon River divide 12 cores were collected. These cores were collected at sites which can be described as having well-drained or moderately well-drained ground soils distributed across convex swells. Ten of these coreholes contained a thick increment of sand between the loess and till. Two coreholes, 16-M5 and M21, contained no sand strata. On the other hand, coreholes collected at poorly drained sites or in swales contained no basal sand increment. Coreholes 16-M9 and M17 are exceptions.

The loess thickness is relatively uniform at these sites. The evidence suggests that the well-drained convex swells on the broad, nearly level primary divide may be underlain by sand dunes. Furthermore, the depressional areas on this same thick loess-mantled surface may be void of subjacent sands. This stratigraphic model is illustrated by the schematic drawing in Figure 41.

The thickness of the oxidized-deoxidized sand free loess at corehole 16-M15 is 180 inches. The thickness of the loess and intercalated sands above the erosional unconformity at corehole M26 is 178 inches although the ground surface at M26 is 5.9 feet lower than the ground surface of M15. The thickness of the loess on the adjacent thick loess-mantled Iowan surface ranges from 151 inches at corehole M7A to 153 inches at corehole M7I to 200 inches at corehole M31. Along the Cedar-Wapsipinicon River divide the loess thickness on the Iowan surface ranges from 144 to 220 inches. This suggests that the oxidized loess of the thick loess-mantled Iowan surface equates stratigraphically with the upper loess of the

Figure 41. Two-dimensional model of thick loess-mantled Iowan erosion surface abutting thick loess-mantled Yarmouth-Sangamon surface


FT. M.
0 0
10
5
20
30
10
40
50 15
60
20
70
LOESS
SANDS
PALEOSOL
TILL
BEDROCK

Bennett paha. In the Geneseo area of Tama County, Fenton (1966, p. 94) reached a similar conclusion for the relationship of the oxidized loess which mantled the Iowan surface as well as the paha.

The results observed in the Lime City transect reveal that the interfluve within a secondary watershed basin have (1) an increment of oxidized loess which is thinner than that found on the primary divide; but (2) the loess deposit maintains a fairly uniform thickness both along the axis of the secondary interfluve as well as normal to the interfluve axis; (3) a sand free deposit of loess is present and no sands occur between the loess and truncated till; and (4) a relative lag-free surface occurs on the truncated till surface.

Along the axis of the secondary interfluve in the Lime City transect the elevation of the truncated till surface decreases from 760.3 feet at corehole M16 to 718.1 feet at corehole M40, a net change of 42.2 feet (Figure 23). The loess thickness decreases from 159 to 115 inches across the same transect.

Approximately 1½ miles southwest of corehole 16-M16 in the west half of sec. 1, T.79N., R.2W., a stable landscape summit on the thick loess-mantled Yarmouth-Sangamon surface reaches an elevation of 812 feet. This suggests that the Iowan erosion surface has cut deeply into the subjacent till along the Lime City transect. The surface of the truncated till is unleached in all cores except for M16, M17, and M40

(Figure 23). In spite of the deep cutting of the till by the Iowan erosion surface the truncated till surface contains no evidence of a coarse lag or pedisediment except at corehole M40 located on the noseslope of the interfluve.

Weathering Zones

In this study weathering zones are identified and reported on the basis of the oxidation state, presence or absence of carbonates, quantity and distribution of organic carbon content, and quantity and distribution of available phosphorus, AP2.

Oxidation zones

Zones of oxidized, deoxidized, and unoxidized loess sediments were identified on the basis of color and mottled patterns. An analysis of the oxidation zones reveal that in the thick loess-mantled Yarmouth-Sangamon surface area the major zones are oxidized - deoxidized - oxidized - unoxidized (Tables 5 and 8; Figure 17). Although the oxidized and deoxidized zones do occur in alternating patterns, the unoxidized zone always occurs in the basal portion of the loess column.

In the thick loess-mantled Iowan surface area the oxidation zones are oxidized - deoxidized - oxidized (Table 7; Figures 12 and 23). However, the deoxidized zone may not always occur. In those coreholes collected at well-drained swells on the landscape the deoxidized zone is absent (Figure 12 and 23). The deoxidized zone is limited to those cores collected from sites located in swale positions on the landscape.

In the loess-mantled Iowan surface area an oxidized zone is the only oxidation zone present.

In the thick loess-mantled Yarmouth-Sangamon area the upper boundary of the upper deoxidized zone occurs at a depth of 9 to 12 feet below the ground surface (Tables 5 and 8; Figure 17). This zone is less than 20 inches in thickness. The upper boundary of the deoxidized zone reflects a pattern that closely resembles the gradient of the ground surface (Figure 17).

The occurrence of oxidation zones do not relate systematically to the lithologic zones in the Bennett paha and associated transect. In the paha an upper and lower deoxidized zone is separated by an oxidized zone. In the thick loess area on the Iowan surface only one deoxidized zone is present (Figure 17). The deoxidized sediments adjacent to corehole M7I are probably related to the saturated conditions which occur in the swale position. The unoxidized zone, when present, is invariably found in the lowest loess increment (Tables 5 and 8; Figure 17).

The relative age of the oxidation zones may be inferred from their distribution in the loess sediments. In corehole M15 the BWP is 25,100 years. The BWP is subjacent to the unoxidized zone. In core M26 (Figure 17) the upper boundary of the unoxidized zone is 21,150 years. This boundary is marked by an organic band which extends along a nearly horizontal plane. In the adjacent core, M15, the band occurs at a depth of 245 inches below the ground surface (Figures 17 and 18). In core M15 nearly 60 inches of unoxidized sediments occur above the organic band. Downslope the unoxidized zone occurs in the basal portion of corehole 16-M28. The BWP is 17,810 years in core M28. The unoxidized zone overlies the BWP and is 10 inches thick at the location.

The evidence indicates that the unoxidized zone ranges in age from at least 25,100 years to something younger than 17,810 years. The zone is present in the basal increment of the thick loess-mantle above the YSS and is present in the basal increment of the thick loess-mantle above the Iowan erosion surface.

The unoxidized zone in the Bennett paha was formed above the nearly level YSS. The results of radiocarbon dating indicate that this zone was formed prior to the local erosional cutting of the Iowan erosion surface except in core M28.

In the unoxidized zone the iron is assumed to be in the reduced state. In this study the unoxidized loess contained an abundant accumulation of flecks and streaks of organic carbon throughout the matrix. Organic carbon analysis of the unoxidized loess in cores 16-M15 and M26 resulted in OC values ranging from 0.59 to 1.06 and 0.49 and 1.50%, respectively.

The evidence presented provides the following conclusions: (1) the unoxidized zone was apparently formed under conditions of ground water saturation or near saturation which allowed for prolonged deficiency of oxygen in the sediments, (2) an abundant cover of hydrophytes grew in this moist environment, and (3) these plants died, decayed and were buried in the moist sediments.

In the Bennett paha and in the loess above the Iowan surface the deoxidized zone is superjacent to the unoxidized zone. Stratigraphically the deoxidized zone must be younger than 21,150 years in the paha and younger than 17,810 years in the loess which mantles the Iowan erosion surface.

The upper deoxidized zone in the Bennett paha is truncated by the paha sideslope (Figure 17). This suggests that the oxidation zone predates the modern hillslope which is probably post-Cary in age. Vreeken (1972, p. 73) has summarized a series of radiocarbon dates for alluvial fill sediments in Wisconsinan loess. These dates taken from the base of gully fills are younger than 8,740 years (Vreeken, 1972). Five miles south of the Bennett paha in the basal fill of Mud Creek, Kramer (1972) reported a date of 6,220 ± 110 years (I-6228). This sample was collected from the top of the sands which form the basal fill sediment. All of these dates imply that the deoxidized sediments are the result of a relict weathering pattern.

Carbonate zones

Zones of leached and unleached sediments were identified. The terms "leached" and "unleached" are used in accordance with standard nomenclature which assumes that in Iowa fresh deposits of loess and till are calcareous. The status of leached and unleached material was determined with 3.0N HCl.

The results demonstrate that in each of the three loess-mantled areas the carbonate zonations differ. In the thick loess-mantled YSS area the carbonate zones in the loess are leached - unleached - leached. In the thick loess-mantled Iowan erosion surface area the carbonate zone sequence is leached loess overlying unleached loess and/or sands superjacent to leached till. In the loess-mantled Iowan area leached loess and sands overlie leached till.

The presence of sands in the loess matrix or at the base of the loess is attributed to redeposition of local sands by aeolian processes. The presence of carbonates in these sediments are due to secondary enrichment by percolating waters.

In the thick loess-mantled YSS area the carbonate zones are leached - unleached - leached. The lower leached zone occurs in the basal increment of the loess. This zone is represented by the BWP and the thickness of the leached zone is limited to the thickness of the BWP. In core M15 the BWP is not completely free of carbonates (Figure 18). The presence of these carbonates may have been due to secondary carbonates being translocated from the unleached overburden. The pH and carbonate values in the subjacent YSP show evidence of a secondary enrichment by translocated carbonates (see core 16-M15, Appendix B). The BWP in cores M28, M27, M28, and M29 is leached.

The leaching of carbonates occur along a leaching front. This front will move downward from the exposed ground surface into the sediment matrix. The lower leached zone, the BWP, represents a relict exposed land surface. Therefore, the BWP is a distinct weathering zone and a separate litho-stratigraphic unit.

In corehole M26, located on the shoulder of the Bennett paha, strata having a leached matrix occur within the unleached weathering zone (Figures 17 and 20). These strata consist of sediment with 43 to 62% sand-sized particles. These strata are superjacent to sediment having an unleached loess matrix. This unleached loess is superjacent to sediment with an un-leached sand matrix.

Downslope, coreholes M27, M28, and M29 have similar sediment-sized stratigraphic relationships. However, in these cores the sand strata occurring in the unleached weathering zone are also unleached.

The leached sand strata in core M26 pose two questions. Does the leaching of these sands post-date the sand deposition or were the sands leached prior to deposition? First, an assessment can be made regarding the presence or absence of carbonates at the time of deposition. It was shown in the areal stratigraphy section that the sands are of a local origin. These sands were distributed as a lag on the truncated till surface, the Iowan erosion surface. The upper till matrix subjacent to the Iowan erosion surface is generally leached (Tables 5 and 8; Figures 12 and 23). Since the till subjacent to the truncated surface is leached the overlying material stripped from this surface was probably also leached. The sands which occurred as a lag on the truncated till surface must have been the residual sediment of the stripped leached material. Then it can be deduced that the sands were probably leached prior to deposition on the flank of the paha. The wind deposited these sands as noncalcareous sediments within the calcareous loess.

Now an evaluation of _in situ_ leaching can be made. The leached sand strata can be traced downslope and is identified in the adjacent coreholes, M27 and M29. In corehole M26 the loess matrix superjacent to the leached sand strata contains carbonates. In coreholes M27 and M29 the superjacent loess is leached.

A lower unleached sand strata in corehole M26 can also be traced downslope and can be identified in the adjacent coreholes. The connecting sand strata in these adjacent coreholes is unleached.

The lateral distribution of both the upper leached and lower unleached sand strata suggests that (1) all strata consisting of predominantly sand-sized particles were deposited in a calcareous matrix or were saturated with carbonates by percolating waters subsequent to deposition. These waters moved along a hydraulic gradient from the adjacent calcareous loess matrix. (2) the sand strata located in the weathering zone matrix on the lower aspect of the hillslope were leached by a downward leaching gradient. (3) the interconnecting sand strata located upslope, but below the downward leaching gradient at their respective position in the weathering zone, were leached by waters which moved downslope along a lateral hydraulic gradient.

The lateral movement and leaching of carbonates along interconnecting sand lens adequately explains the occurrence of leached sand strata within a calcareous loess matrix.

In the thick loess-mantled Iowan surface area the carbonate zonation within the loess is characterized by a leached zone over an unleached zone. The thickness of the upper leached zone ranges from 61 to more than 130 inches at sites where the ground soil was identified as well drained. Usually the loess deposit is superjacent to leached till. Some exceptions were noted where the till was identified as unleached.

In coreholes 16-M1, M3, M6, M7A, M8, M9, M10, M11, M12, M16, M17, M20, M30, M32, and M40 an increment of sand occurs between the loess and till. These increments of sand are enriched with carbonates except for those sand strata in cores M9, M12, and M20. Why are the sands calcareous at some sites but not at other sites? The calcareous sands are probably the result of a secondary enrichment by carbonates. The carbonates were apparently translocated by water from the overlying loess.

In the areal stratigraphy section the distribution of the sands on the truncated till surface were described as being piled into dune-like features by the wind. With the exception of the basal increment of sands found at corehole M17, there is no evidence to indicate that these sands form a continuous network across the truncated paleosurface.

The downward percolating waters apparently caused the translocation of carbonates into the sand zones. When these waters reached the underlying till surface lateral movement occurred due to the difference in bulk density and porosity of the till and overlying sands. The sands are discontinuous and are absent beneath the modern landscape, which is accentuated by swales. The sand strata does not continue downslope between the loess-till contact, especially in those areas adjacent to the buried drainageways. Then there is no porous sediment along the hydraulic gradient for the carbonates to be flushed into. Therefore the carbonates are entrapped within the closed sand zone which results in the sands having a calcareous matrix.

An adequate explanation for the leached sand zones in cores M9, M12, and M20 is not available. These cores were collected as part of the reconnaissance traverse. Therefore, detailed stratigraphic information regarding adjacent sites is not available.

Organic carbon zones

Accumulations of OC in the weathering profile are restricted to the loess deposits in the area characterized by the thick loess-mantled YSS. The analysis of the weathering zones in cores from the Bennett paha for OC resulted in the determination of OC values as high as 1.50% in the unoxidized zone (Figures 18 and 20). In addition, at coreholes M15 and M26 OC values up to 0.60% were obtained in the oxidized and deoxidized zones subjacent to the ground soils (Figures 18 and 20).

At the Bennett paha the OC values of 1.50% and less occur in the unoxidized and unleached zone. These OC data provide additional validity for an explanation of the genesis of these unoxidized zones. It was shown in the background section that these zones have higher ferrous iron contents than do the oxidized and deoxidized zones (Daniels et al., 1961). Also the unoxidized matrix changes color on exposure to air. These factors suggest that the unoxidized zone was formed in a saturated or near saturated condition. The evidence of OC in this zone supports the hypothesis that plants grew on the sediments, then died, decayed and were buried within the moist sediments.

In cores M15 and M26 the OC is not evenly distributed throughout the unoxidized zone (Figures 18 and 20). Horizons of increased OC content can be identified. Apparently more plant material accumulated at these horizons. These horizons are interpreted as paleosurfaces which mark a longer period of stability during loess deposition than the superjacent and subjacent horizons.

Organic carbon values of 0.60% and less were measured in the deoxidized and unleached zone of the Bennett paha (Figures 18 and 20). This portion of the loess profile is above the unoxidized zone and is younger than 21,150 years. As previously discussed, the loess above the unoxidized zone is stratigraphically related to the loess-mantle on the Iowan surface.

These OC values may be related to the OC content of the loess at the time of deposition or related to OC accumulations which occurred on the loess paleosurfaces. Organic carbon accumulations on the loess paleosurfaces can be interpreted as intervals representing pauses or breaks in the loess deposition. Similar pauses or breaks in loess deposition have been identified in the loess of western Iowa (Handy and Davidson, 1956; Daniels et al., 1960; Ruhe et al., 1971).

There is no evidence in the literature or in the data collected in this study to support the hypothesis that the loess was enriched in OC at any time prior to deposition. Therefore, the OC must have accumulated during breaks in the loess deposition. In corehole 16-M15 the sample horizon at 127 to 133 inches has 0.59% OC. The overlying horizon contains 0.44% OC and the underlying horizon contains 0.36% OC. This suggests that the sample horizon extending from 127 to 133 inches represents a weakly developed weathering profile in the loess. However, in cores M15 and M26 the OC values range from 0.20 to 0.45% throughout the oxidized and deoxidized loess matrix below a depth of approximately 100 to 120 inches of the ground surface. These values are 0.20 to 0.30% higher than would be predicted based on results reported from like weathering zones in other areas of the state. The reason for these higher OC values may be related to the method of calculating OC values. In this study OC values in unleached zones were determined by the difference between total carbon and the amount of total carbon attributed to carbonates.

In summary, the evidence suggests that the loess at the Bennett paha has experienced pauses or breaks during the time of deposition. These pauses are marked by an increased percentage of OC within the loess matrix. Also, OC values of 1.50% are present in the unoxidized zone within the lower loess increment.

<u>Available phosphorus distribution</u>

The results of available phosphorus distribution within the weathering zone showed: (1) a high accumulation in the A horizon of the ground soil, (2) followed by a sharp decrease to less than 10 ppm in the A3-B1 horizon of the ground soil, and (3) the maximum subsurface accumulation occurred in the lower textural B horizon with measurement by AP1 and subjacent to the solum with measurement by AP2. The distribution of available phosphorus below the solum indicates that transformations of phosphorus can be qualitatively measured by the AP2 procedure. The AP1 procedure does not measure these phosphorus transformations (Figures 18 and 20).

The distribution of AP1 below the textural B horizon is dependent on whether the loess is leached or unleached. The AP1 distribution gradually decreases in ppm as the sample horizons approach the base of the leached zone (Figures 18 and 20). In the unleached zone AP1 distribution shows no measurement of phosphorus transformations.

The distribution of AP2 below the base of the solum indicates that the maximum amount of Ca-phosphate transformation, which is measured by the AP2 method, occurs subjacent to the zone of maximum clay transfers and transformations. Other zones of phosphorus transformation can be identified by determination of AP2 in the loessial weathering profile (Figures 18 and 20).

The weathering zone distribution of AP2 requires an evaluation as to whether these phosphorus transformations have any usefulness or potential in subsolum investigations. First, what relationship, if any, occurs between the AP2 maximum and the weathering profile subjacent to the solum. Second, is there a relationship between variations in the AP2 distribution and the weathering profile at lower depths in the loess column. Is the AP2 related to the distribution of other forms of phosphorus. Finally, can AP2 be used as a criterion for the differentiation of degrees of weathering.

The AP2 procedure extracts a portion of the acid-extractable form of P, the Ca-phosphate. The quantity of the total acid-soluble P extracted by this method is not known. It was not the intent of this study to quantify that aspect of the procedure.

The AP2 distribution in core 16-M15 can be related to four weathering zones: (1) the solum, (2) the oxidized and leached zone subjacent to the solum, (3) the unleached zone, and (4) the subjacent YSP.

The solum represents the zone of maximum transformation and eluviation of phosphorus. The inorganic phosphates are moved upward and recycled by plants, transformed, and moved downward by percolating waters.

The oxidized and leached zone subjacent to the solum represents the zone of illuviation and accumulation. In this zone the pH values range from 5.8 to 7.0. The bulk of the phosphates in this zone are likely in the form of Ca-phosphate based on studies of Chang and Jackson (1958). The accumulation of Ca-phosphates in this zone probably are due in part to the downward movement of Ca-phosphates by percolating waters and the lack of removal by plants.

The unleached zone represents a zone of limited solubility. In this zone pH values are greater than 7.6. The solubility of Ca-phosphates decreases rapidly as the pH increases (Lindsay and Moreno, 1960; Smeck, 1973). In this zone an AP2 differential occurs between the deoxidized zone and the unoxidized zone. No significant change in pH occurs between these two oxidation zones (see data for core 16-M15, Appendix B). Carbonate values (Figure 18) are generally twice as great in the deoxidized zone as in the unoxidized zone. The reason for the AP2 differential cannot be identified from the available data.

The lower weathered zone, the YSP, represents a zone of accumulation and solubility. At the BWP-YSP interface a sharp increase in AP2 occurs (Figure 18). This is interpreted as an accumulation of Ca-phosphates caused by percolating waters from the superjacent loess column. The pH in this zone ranges from 7.0 to 7.2. In this pH range Ca-phosphates are most soluble.

The distribution of AP2 in the upper 90 inches of core 16-M26 (Figure 20) is quite similar to the distribution reported for core 16-M15. Below 90 inches the distribution is dissimilar. From a depth of 90 to 185 inches in core 16-M26 the AP2 distribution is related to the particle size of the sediment matrix. The model for this distribution was described in the results section. Below a depth of 185 inches the AP2 distribution appears to be related to the OC bands. An accumulation of AP2 occurs just below the surface of the OC bands except for the OC band at 235 inches. Overall the AP2 in the unoxidized zone is less than in the oxidized zone.

The AP2 distribution in the weathering profile is similar to the total phosphorus (TP) distribution reported for weathering profiles. Data reported by other investigators (Fenton, 1966; Runge and Riecken, 1966; Smeck and Runge, 1971; McKim, 1972; Huddleston and Riecken, 1973; Runge et al., 1974) have indicated that the maximum TP in a loessial weathering profile occurs in the lower portion of the textural B horizon or more commonly in the zone subjacent to the B horizon of the ground soil. Runge and Riecken (1966) proposed the following TP designations for loessial weathering profiles: (1) 0 to 3 feet, P eluvial horizon; (2) 3 to 6 or 8 feet, P illuvial horizon; and (3) below 6 to 8 feet, P parent material.

In leached loessial weathering profiles from New Zealand Runge et al. (1974) reported that the Ca-phosphate distribution is closely related to the distribution trend of the TP in all horizons except for the surface soil. In their study (Runge et al., 1974), they successfully related the distribution of Ca-phosphates and TP to paleosolic zones in the weathering profile. The distribution of AP2 in core M15 cannot be conclusively related to zones of OC or clay accumulations except for the lower weathering zone, the YSP. The failure of AP2 to be used as diagnostic criterion for identification of incipient paleosols is due to the accumulation of carbonates and the calcareous matrix below 100 inches (Figure 18).

However, the AP2 does indicate that phosphorus transformations occur in the weathering profile. Then AP2 analysis can be used as a qualitative measurement to identify changes which have occurred in the loessial weathering profile.

In summary, the distribution of available phosphorus in the weathering profile identifies the zone of minimum and maximum accumulations of Ca-phosphates in the leached zone. Below the leached zone AP1 distribution provides no diagnostic measurement of phosphorus transformations. However, AP2 analysis indicates that a large quantity of Ca-phosphates are accumulated in the zone adjacent to the solum. Also, the AP2 analysis suggests that phosphorus transformations occur in the weathering profile. These transformations may be related to pauses or breaks in the loess deposition as well as to changes in the dominant particle size of the sediment matrix.

Proposed oxidation zone terminology

Oxidation zones are identified and classified in the field on the basis of color and the presence or absence of mottles. In this dissertation the hue, chroma, and value guidelines proposed by Fenton (1966) have been used to define oxidation states. In the background section it was shown that the oxidation state of iron is inferred, based on the color of the sediment matrix. However, data (Daniels et al., 1961) for ferric and ferrous oxides do not always agree with inferred interpretation of the presence of iron in a specific weathering zone. In addition, it is unreasonable to imply that an unoxidized zone is present in the basal loess increment. The concept of oxidation is based on redox potential of oxidation or reduction. In the case of a basal loess increment, the terms unoxidized and reduced are not synonymous. In terms of their present usage the implication is that unoxidized and reduced are one and the same. Without the availability of chemical data on the status of iron in the weathering zone it is impossible to make accurate determinations for the oxidation state of iron. The alternate solution is to define a weathering zone on the basis of its dominant color and the presence or absence of carbonates.

The purpose of this section is to propose a set of terminology, based on hues, chroma, values, and mottling, to characterize weathering zones in unconsolidated sediments.

There are two approaches which can be used to adequately define weathering zones. One method would be to use numbers for each zone. The other solution is to use concise names.

A numbering system was first proposed by Leighton and MacClintock (1930). The most serious disadvantage in that system is that numbers, when used this way, are abstract.

The application of coined names which are short, phonetic, and mnemonic was proposed and adopted for soil classification purposes (Soil Survey Staff, 1960). Brewer (1964) has been successful in defining concise names for features and arrangements of morphological details in soil materials. The coining of connotative names that are based on the dominant colors of each weathering zone provides for easy recall of precisely defined color zonations. The proposed color zonations are coined terms derived from adjectives which connotate color and color schemes.

The name "brunambric" is proposed and would be characterized by having 60% of the matrix with hues of 2.5Y or redder, values of 3 or higher, and chroma of 2 or higher, with or without gray mottles. The term "brun" is from the Anglo-Saxon adjective brunet meaning brown. The term "ambric" is derived from the French word amber meaning reddish-yellow. The name "brunambric" would be used in lieu of oxidized.

The second proposed name is "pallic". This zone would be characterized by having 60% of the matrix with 2.5Y and 5Y hues, values of 5 and 6, chromas of 1 and 2, with segregations of "brunambric" or yellowish-red, yellowish-brown, brown, and olive brown materials into tubules and/or nodules. The term "pallic" is derived from the Latin word <u>pallidus</u> meaning pale. Perhaps a more connotative term for this color zone would be ochric. However, an ochric horizon has been previously defined as part of the soil classification scheme (Soil Survey Staff, 1960). The term "pallic" would be used in lieu of deoxidized.

The name "glaucic" is proposed for those zones in the weathering profile characterized by matrices of 5Y, 5GY, 5BG, 5B, and 5G hues, values of 4, 5, and 6, chromas of 0 and 1, with no segregation of materials having redder hues or higher chromas. The term is derived from the Greek word glaukos meaning bluish-green or gray. The term "glaucic" would be used in lieu of unoxidized.

Soils

In the results section emphasis was on similarities and differences in well and moderately well drained Mollisols formed on loess parent materials. Soil profiles were grouped into three soil groups on the basis of similar characteristics which could be identified in the field. Soil group No. 1 includes profiles 16-M21, M34, and 82-M1. Soil group No. 2 includes profiles 16-M1, M3, M5, and M6. Soil group No. 3 includes profiles 16-M5, M18, and M41.

The soils collected for evaluation in this study are from the Tama-Muscatine and Dinsdale-Tama soil association areas (Figure 3).

Three of the objectives listed in the introduction section will be discussed in this section. First, a comparison is made of the characteristics of representative Tama soils from east-central Iowa to the well and moderately well drained Mollisols of Cedar and Scott counties. Second, the changes in similar and dissimilar soils across a small, defined landscape will be reviewed. Third, results of soil properties will be discussed in terms of degree and intensity of weathering of the subsoil.

Representative Tama soils from east-central Iowa which were selected for comparison are profiles S59-Iowa-86-1 (Soil Survey Staff, 1966), PAL-1, WZ-1, and a representative Tama bench phase, GS-4 (Fenton, 1966). Profile S59-Iowa-86-1 will be referred to as 86-1 in this dissertation. Data for these units are listed in Table 13. Dominant characteristics of profile 86-1 are all within the range of the modal Tama taxonomic unit. Profiles PAL-1 and WZ-1 have mottles at depths of less than 36 inches. Both profiles are classified as being moderately well drained (Fenton, 1966). Profile GS-4 is well drained and the solum is superjacent to sands which were contacted at 39 inches below the ground surface. Also, both profiles WZ-1 and GS-4 have some grainy gray ped coatings in the B horizon (Fenton, 1966).

Selected profile characteristics for profiles 86-1, PAL-1, WZ-1, and GS-4 are compared to the profiles in soil groups 1, 2, and 3 in Table 14. A general summary obtained from the results section for soils from the study area are outlined in the following paragraphs.

Summary of results

Clay The clay distribution in the solum for soil group No. 1 is similar to the distribution determined in the representative Tama soils (Figures 24 and 42). The clay distribution and clay maximum for soils in soil groups No. 2

Table 13. Data for representative profiles of Tama silty clay loam

Depth (inches)	GM[a] (μ)	% < 2 μ	% OC	pH 1:1	CEC meq/100g	EA meq/100g	AP1[b] ppm	CEC/< 2 u
S59 Iowa-86-1[c]								
0-6.5		28.6	2.35	5.7	20.6	9.3		0.72
6.5-11		32.2	1.95	5.8	21.4	11.4		0.66
11-16.5		34.2	1.42	5.7	23.8	9.6		0.70
16.5-20		35.6	0.97	5.8	24.0	8.5		0.67
20-25		35.4	0.68	5.7	23.6	8.1		0.67
25-29		33.2	0.45	5.7	22.8	7.6		0.69
29-35		30.5	0.34	5.7	21.7	6.8		0.71
35-45		28.2	0.21	5.8	20.9	6.1		0.74
45-51		28.5	0.15	6.1	20.3	5.1		0.71
51-61		27.6	0.12	6.5	20.1	4.1		0.73
PAL-1[d]								
0-7	18.7	29.2	2.50	5.3	26.6	8.0	20.0	0.91
7-11	18.4	31.2	2.30	5.3	27.2	8.0	14.0	0.87
11-16	18.0	32.4	1.60	5.3	25.2	6.4	8.7	0.78
16-21	18.7	33.2	1.20	5.4	25.7	6.1	6.6	0.77
21-25	19.4	33.8	0.90	5.4	26.7	5.5	10.2	0.79
25-29	18.7	33.2	0.60	5.5	27.4	4.6	18.1	0.82
29-34	19.0	31.2	0.40	5.6	27.1	4.3	28.5	0.87
34-40	20.4	29.1	0.30	5.6	25.8	3.1	30.0	0.89

[a]Geometric mean. Calculated by author.

[b]Available phosphorus, Bray 1. Data not in original publication. Analysis performed in Iowa State Soil Survey Laboratory, 1972.

[c]Extracted from Soil Survey Staff (1966).

[d]Extracted from Fenton (1966).

Table 13. (Continued)

Depth (inches)	GM (μ)	% < 2 μ	% OC	pH 1:1	CEC meq/ 100 g	EA meq/ 100 g	AP1 ppm	CEC / < 2 u
40-46	22.7	27.6	0.20	5.8	24.9	2.8	28.5	0.90
46-52	22.1	25.2	0.20	6.0	24.5	2.1	22.1	0.97
52-60	22.3	23.7	0.20	6.4	23.4	1.1	6.3	0.99
				WZ-1[d]				
0-7.2	20.8	27.3	2.10	5.9	23.8	5.5	23.0	0.87
7.2-13	19.3	29.8	1.60	5.6	22.1	5.7	11.8	0.74
13-16	19.3	30.8	1.20	5.3	21.9	5.6	11.8	0.71
16-19	19.3	31.2	1.10	5.4	22.4	5.3	10.0	0.72
19-23	19.4	31.0	0.80	5.2	23.0	4.8	12.2	0.74
23-28	20.6	30.9	0.60	5.2	23.8	4.4	14.5	0.77
28-33.6	21.7	29.8	0.40	5.3	23.1	4.0	28.8	0.77
33.6-38	21.2	28.5	0.30	5.3	22.8	3.9	38.0	0.80
38-42	22.5	27.9	0.20	5.5	22.8	3.6	44.0	0.82
42-48	22.5	26.9	0.20	5.6	21.7	3.2	38.0	0.81
48-54	23.8	25.6	0.10	5.7	21.9	3.0	32.2	0.86
				GS-4[d]				
0-10	19.5	25.9	1.97	5.6	21.6	5.3		0.83
10-18	18.9	29.6	1.48	5.1	21.0	7.2		0.71
18-22	18.4	30.1	1.11	5.2	20.2	6.0		0.67
22-32	19.2	30.5	0.62	5.3	22.2	4.9		0.73
32-39	20.6	31.8	0.41	5.2	23.2	4.4		0.73
39-47	45.8	23.7	0.30	5.3	17.2	3.8		0.73
47-55	67.2	14.6	0.26	4.6	10.6	2.6		0.73
55-62	85.4	4.9	0.15	5.4	3.5	0.9		0.71

Table 14. Selected characteristics of well and moderately well drained Mollisols

Property	Representative Tama soils			Tama bench phase	Soils group No. 1		
	Ia-86-1	PAL-1	WZ-1	GS-4	M21	M34	82-M1
Depth to gray mottles (in.)	45	29	33.6	--	43	51	42
% clay maximum	35.6	33.8	31.2	31.8	34.2	32.4	33.2
Depth to % clay max.	18	23	17.5	32	19	24	22
Weighted % clay (0-15")	31.2	30.6	28.8	27.1	28.4	28.6	28.4
Weighted % clay (8-25")	34.5	32.7	30.6	29.4	32.0	31.4	32.0
Weighted % clay (10-40")	32.6	31.9	30.1	30.3	31.3	30.9	31.3
B/A ratio	1.24	1.16	1.14	1.23	1.27	1.21	1.31
Max. argillic ratio	1.24	1.25[a]	1.14	1.17	1.27	1.21	1.26
Max. AP1 (ppm) in subsoil	--	30.0	44.0	--	32.0	35.0	33.6
Depth to max. AP1 (in.)	--	37	40	--	32	33	35
Depth to min. pH below A horizon (in.)	20	21	19	47	25	26	16
Weighted pH (10-40")	5.5	5.5	5.3	5.6	5.9	6.3	5.5
Depth to <0.58% OC (in.)	25	29	28	32	21	22	19
Weighted OC (8-25")	1.20	1.44	1.13	1.30	0.93	0.98	0.79
Weighted OC (0-15")	1.98	2.21	1.79	1.81	1.69	1.97	1.55
Weighted CEC (10-40") meq/100 g	22.7	26.3	22.8	21.7	25.2	23.1	--

[a]Argillic ratio in lower cambic horizon: 29-34" and 46-52".

Table 14. (Continued)

Property	Soils group No. 2				Soils group No. 3		
	16-M1	M3	M6	M8	M5	M18	M41
Depth to gray mottles (in.)	26	41	42	45	40	47	51
% clay maximum	34.3	32.1	31.5	32.8	29.9	28.0	29.5
Depth to % clay max.	41	38	44	47	25	32	25
Weighted % clay (0-15")	24.9	26.2	28.0	27.6	25.7	21.9	26.2
Weighted % clay (8-25")	26.3	29.2	29.2	29.0	28.2	25.4	28.4
Weighted % clay (10-40")	28.9	29.2	29.7	29.5	28.8	26.4	28.3
B/A ratio	1.37	1.27	1.16	1.23	1.21	1.33	1.18
Max. argillic ratio	1.20	1.17	1.27[b]	1.37[c]	1.19	1.31	1.16
Max. AP1 (ppm) in subsoil	42.5	23.5	37.5	28.0	35.5	39.9	45.5
Depth to max. AP1 (in.)	54	34	55	71	72	45	49
Depth to min. pH below A horizon (in.)	16	22	25	20	23	29	31
Weighted pH (10-40")	5.4	5.7	5.5	5.3	5.0	6.4	5.8
Depth to <0.58% OC (in.)	20	22	21	26	16	29	27
Weighted OC (8-25")	1.17	1.08	1.11	1.12	0.84	1.56	1.18
Weighted OC (0-15")	2.63	1.97	1.68	1.82	1.70	2.26	1.68
Weighted CEC (10-40") meq/100 g	19.9	19.4	19.9	19.1	19.3	18.9	17.7

[b]Argillic ratio in lower cambic horizon: 42-47" and 58-64".

[c]Argillic ratio in lower cambic horizon: 45-50" and 61-68".

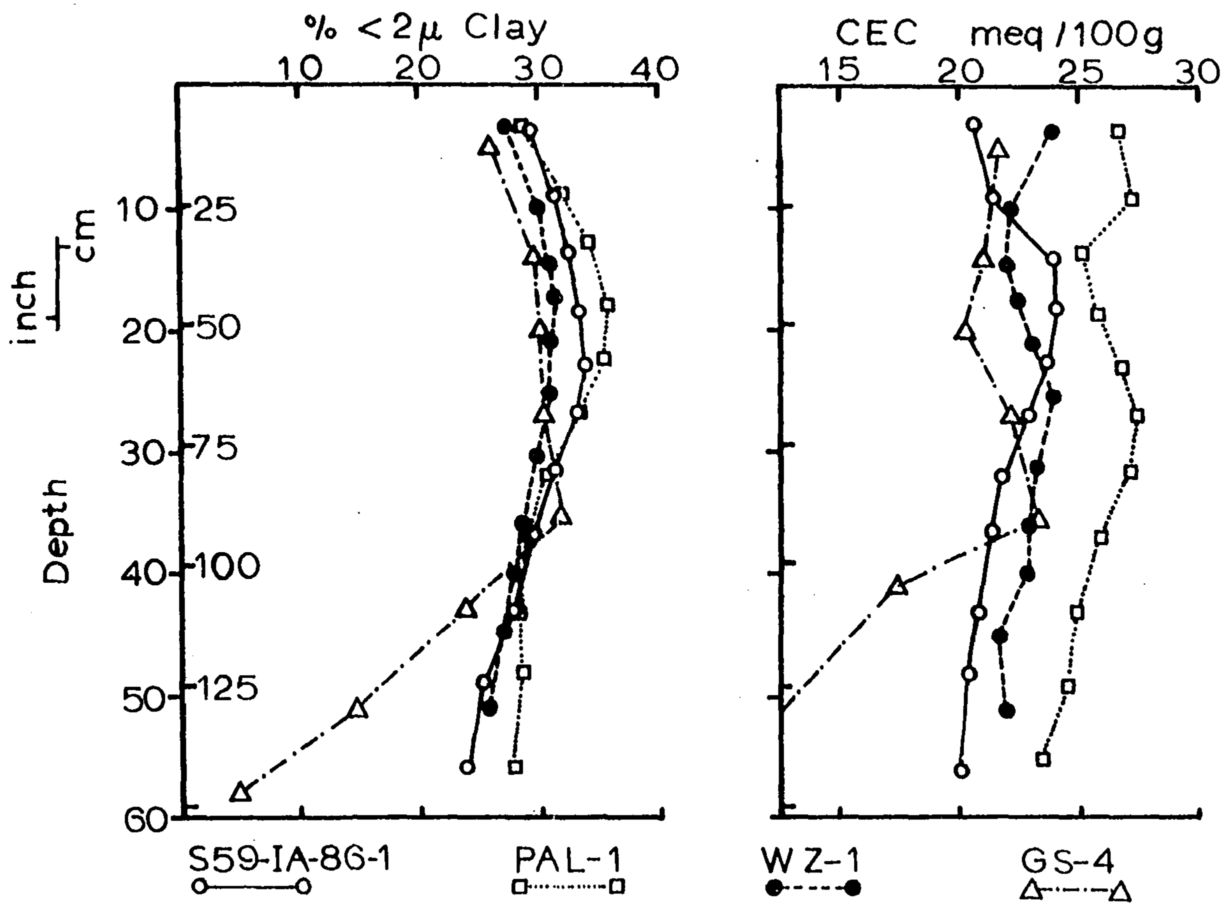


Figure 42. Clay and CEC distribution versus depth for representative Tama soils from east-central Iowa (data plotted from Soil Survey Staff, 1966, and Fenton, 1966)

and 3 are at a lower depth in the soil profile and have lower percentages (Figures 27 and 30; Table 14).

Available phosphorus   The AP1 distribution in the soil profile for soils in soil group No. 1 is similar to the distribution determined for profile PAL-1 (Figure 25; Table 13). The AP1 distribution for soils in soil groups No. 2 and 3 have higher maximum AP1 values and greater depth to the AP1 maximum (Table 14).

Cation exchange capacity   The CEC distribution for the Tama profiles is plotted in Figure 42. The CEC values for profiles PAL-1, WZ-1, and GS-4 were determined by summing the exchangeable bases and exchangeable hydrogen (Fenton, 1966). The CEC values for profile 86-1 and profiles in soil groups No. 1, 2, and 3 were determined by NaOAc method at pH 7.0. The summing of the cations method generally yields higher exchange capacity values. This is because no two reagents for extracting exchangeable cations or for saturating the soil in the determination of CEC will provide the same results for the same sample (Black, 1968, p. 209). However, by either method of CEC determination the shape of the CEC distribution curve with depth in the profile should be analogous.

The results show that all profiles expressing some amount of grainy gray ped coatings in the solum have a sharp decrease in CEC near the base of the A horizon. This decrease in CEC occurs between the lower A horizon and the CEC maximum in the B horizon. This CEC distribution is characteristic of all profiles from eastern Iowa and profiles PAL-1, WZ-1, and GS-4 from Tama County, Iowa (Figures 26, 29, 32, and 42). The CEC distribution in profile 86-1 does not have this distribution inflection.

pH The pH distribution for the representative Tama profiles is listed in Table 13. The pH distribution for soil profiles in soil groups No. 1, 2, and 3 have one or more profiles with pH values 0.5 to 1.5 units higher than the representative Tama profiles. These higher pH values occur from the ground surface down to a depth of 20 inches or more (Table 13; Figures 26, 29, and 32). However, weighted pH values for the 10 to 40-inch zone do not provide a characteristic trend (Table 14). In fact, weighted pH values for all profiles in soil group No. 2 are most closely correlated to pH values obtained for the representative Tama profiles (Table 13).

Exchangeable acidity The profile distribution of EA for soils in soil group No. 1 and 16-M41 in soil group No. 3 are similar to the profile distribution identified in profile WZ-1 (Table 13; Figures 26, 29, and 32). The EA distribution in the remainder of the profiles from eastern Iowa is similar to the depth distribution recorded for profiles 86-1 and PAL-1.

Organic carbon The representative Tama soils from east-central Iowa have a greater thickness of high OC content than do the soils from eastern Iowa (Tables 13 and 14; Figures 26-, 29, and 32). In eastern Iowa, profiles 16-M18 and M41 (soil group No. 3) have comparable OC distributions.

The role of organic carbon and clay

The production of high quantities of organic matter stabilizes the upper horizons of the solum and inhibits soil development. The stage of soil development is characterized by clay distribution in the B horizon. Shrader (1950) demonstrated that prairie-derived soils in different stages of development had a lower clay ratio for the A and B horizons than did transitional or forest-derived soils which were also in different stages of development. Smeck and Runge (1972) hypothesized that soil development was retarded by increased organic matter production because: (1) greater recycling of bases, (2) increased buffering capacity, (3) retardation of mineral weathering due to protective organic coatings on the mineral surfaces, and (4) decreased surface area exposed to the weathering forces due to the formation of stable soil aggregates.

The 8 to 25-inch zone was weighted for percentage of OC and clay for the soils in soil groups No. 1, 2, and 3, as well as the representative Tama profiles. The results are listed in Table 14. The 8 to 25-inch zone was selected because this zone would have: (1) less disturbance than the superjacent material because of agriculture practices, (2) curvilinear OC distribution with depth, and (3) a range in end-values for percentage of clay content.

In order to determine differences in well drained Mollisols from separate geographic areas the soil profiles from Scott and Cedar counties were analyzed apart from the representative Tama profiles. A significant relationship exists between the weighted clay and OC values for the eastern Iowa soils (Figure 43). However, this regression equation (Figure 43) is valid only for those soils from eastern Iowa formed on 1 to 3% slopes. The validity of the regression equation can be tested by inserting weighted clay and OC values from other profiles collected from steeper slopes (Table 15). For example, profiles 16-M7A and M7B (Table 15) are located on 2% slopes along the Bennett transect. The other four soils (Table 15) are located on 6 to 9% slopes along the same transect. When these values (Table 15) are plotted in Figure 43 the points for profiles M7A and M7B will approximate the regression line. However, the points for the other four profiles will be located well out of the range of the standard error of the regression line. A similar condition applies for the representative Tama soils and the Tama bench phase soil (Table 15).

This analysis (Figure 43) suggests that a strong correlation exists between the production of organic matter and clay accumulation for well and moderately well drained Mollisols from similar slopes within a limited geographic area.

The exchange capacity

Cation exchange capacity is a function of the active exchange surfaces present. In soils the active exchange surfaces

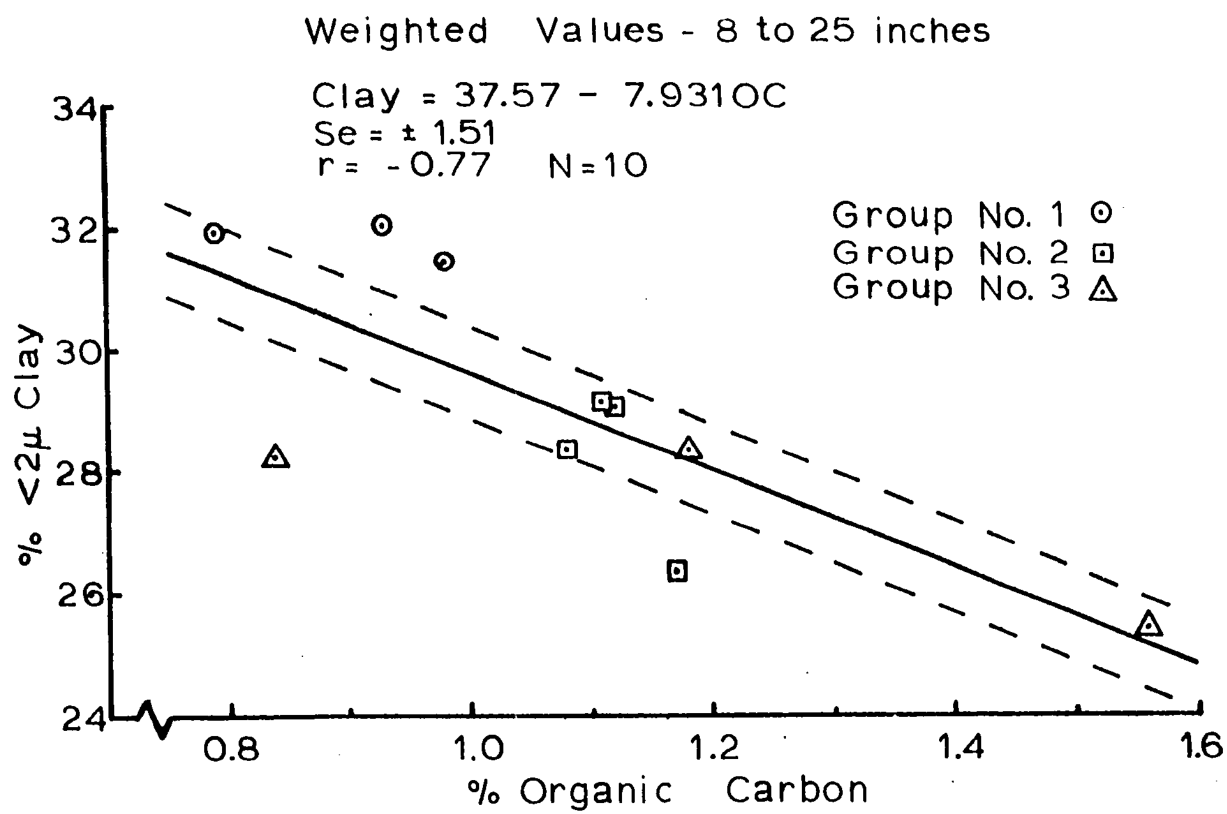


Figure 43. Plot of weighted clay values versus weighted OC values for soils of soil groups No. 1, 2, and 3

Table 15. Weighted percentage clay and organic carbon in the 8 to 25-inch zone, for selected profiles, Cedar County, Iowa

Property %	Profile number					
	M7A	M7B	M26	M27	M28	M29
Clay	28.7	29.7	30.5	30.2	29.6	30.3
OC	1.32	0.99	0.75	0.45	0.73	0.28

will be dependent on the amount of fine clay, the type of clay minerals, and the amount and kind of organic matter present.

The close relationship of CEC, OC, and clay in soils has long been recognized (Williams, 1932; Pratt, 1957; Hallsworth and Wilkinson, 1958; Helling, Chester, and Corey, 1964; Wilding and Rutledge, 1966). However, only Wilding and Rutledge (1966) have attempted to study the CEC, OC, and clay relationship with solum depth. They found that organic matter contributed most to the CEC in A horizons, whereas the fine clay, the < 0.2 μ clay-sized particles, contributed the greatest to the CEC of the B horizon. This observation for exchange capacity in the B horizon is in agreement with earlier studies reported by Whitt and Baver (1930) regarding specific surfaces.

The role of organic matter in the CEC of soils is complex. Experiments conducted by Schofield (1950) gave rise to the concept which indicates that part of the exchange positions are "pH dependent". This concept showed that increasing pH values resulted in increased exchange capacity. McLean, Huddleson, and Post (1959) demonstrated that the CEC from organic matter is pH dependent due to the weak acid bond dissociation which is highly buffered against pH change. For example, in A horizons, Helling et al. (1964) reported that at pH 2.5 the contribution of the clay fraction to the total CEC was five times that of the OC. At pH 8.0 the clay fraction contributed only 1.4 times more to the total CEC.

The distribution of CEC, OC, clay, and pH is plotted for profile 86-1 and select profiles from the soil groups of Cedar and Scott counties (Figures 44, 45, 46, 47, and 48). In profile 86-1 the CEC distribution parallels the plot representing the clay distribution. The pH is less than 6.0 throughout the profile.

A different pattern is observed in profile 16-M21 (Figure 45). The CEC is related to the distribution of OC and pH to a depth of 20 inches. Below 20 inches the CEC distribution responds to the clay distribution. The fact that the CEC apparently does not respond to the higher pH values in the lower B horizon is due to the absence of OC and the suppression of acid bond dissociation.

In profile 16-M34 (Figure 46) the high pH values in the A horizon do not affect the CEC distribution to the same degree as shown in profile 16-M21 (Figure 45). The difference may be explained by the differential in the weighted 0 to 15-

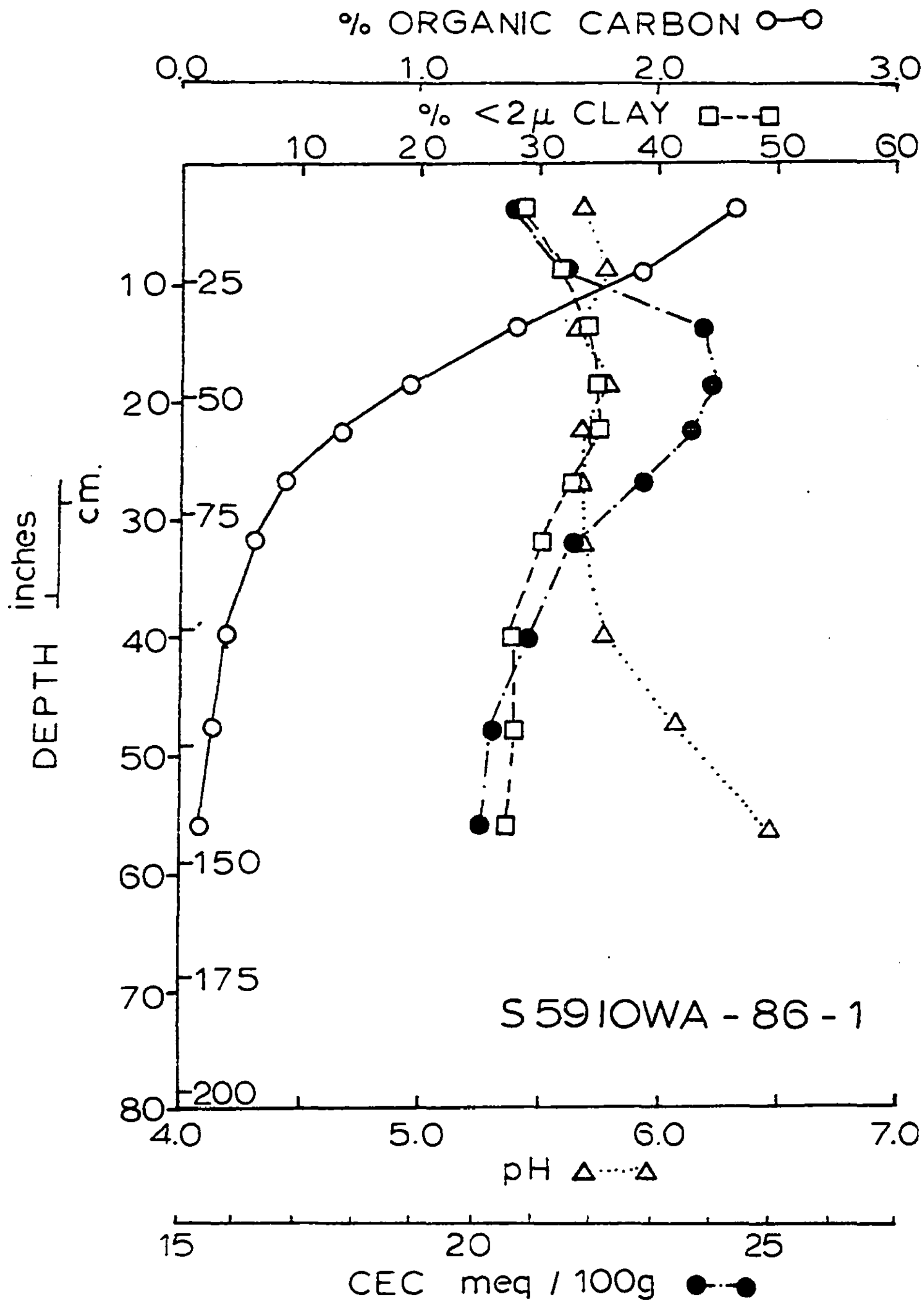


Figure 44. OC, clay, pH, and CEC distribution versus depth for profile S59-Iowa-86-1 (data from Soil Survey Staff, 1966)

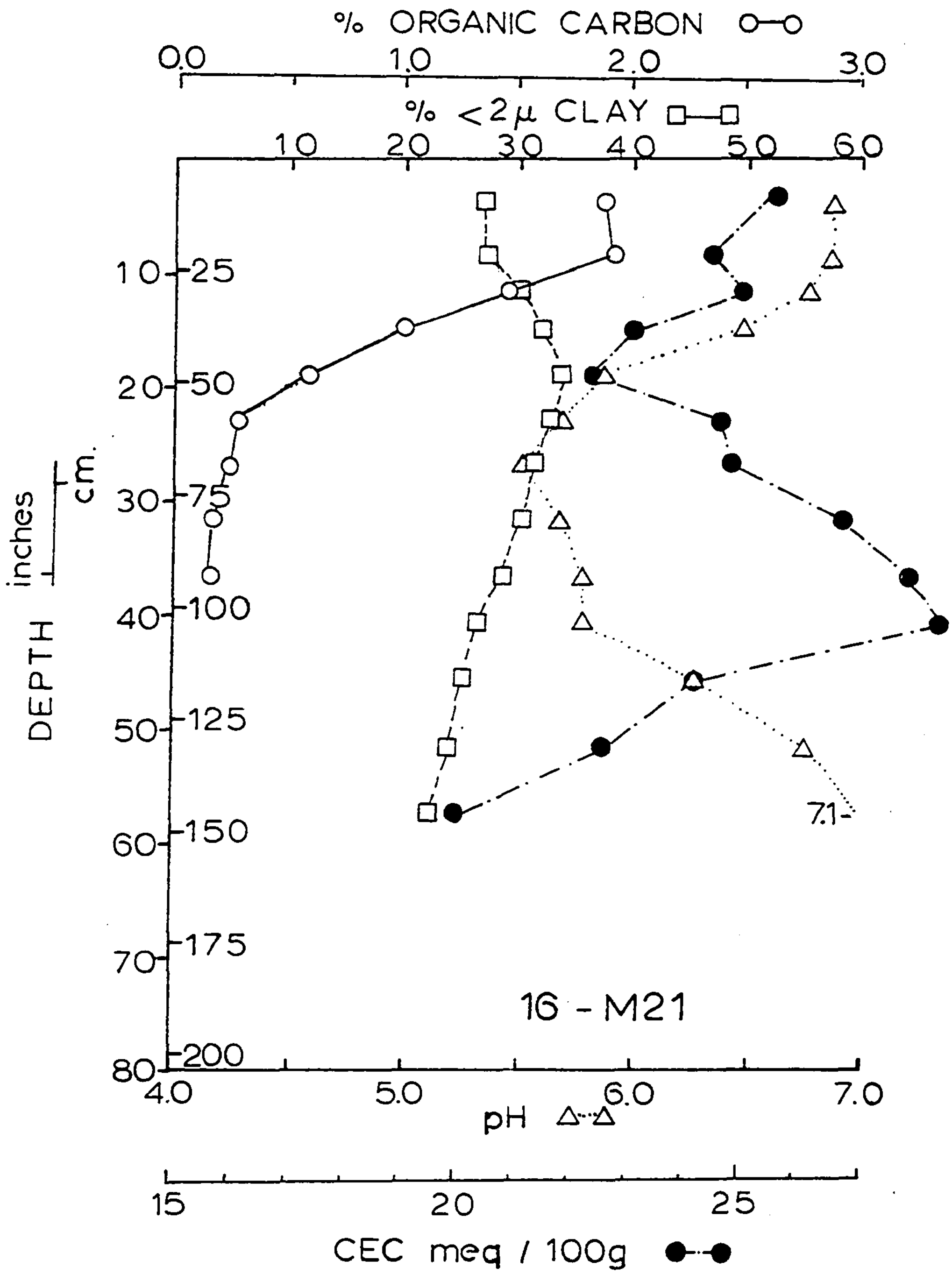


Figure 45. OC, clay, pH, and CEC distribution versus depth for profile 16-M21

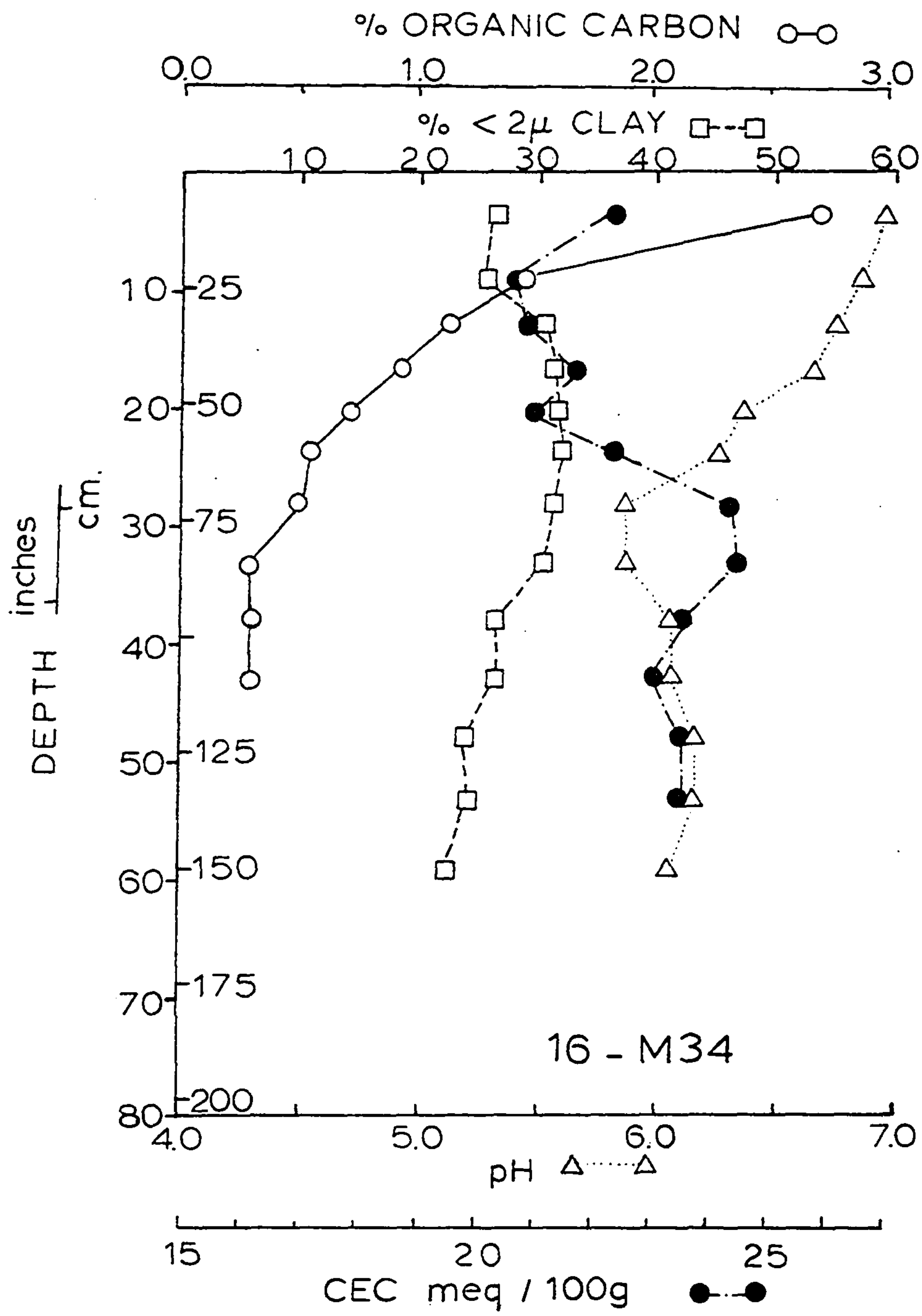


Figure 46. OC, clay, pH, and CEC distribution versus depth for profile 16-M34

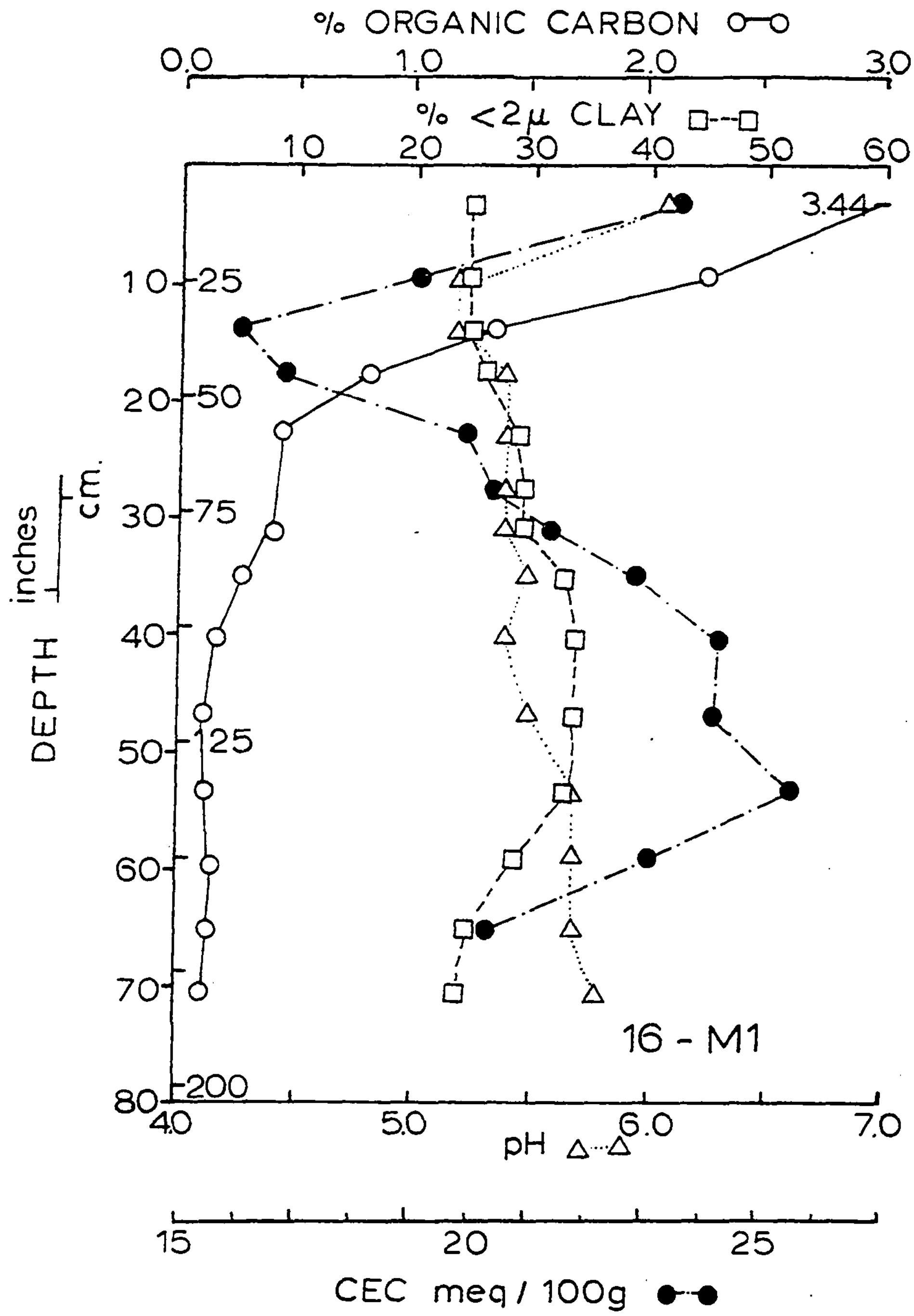


Figure 47. OC, clay, pH, and CEC distribution versus depth for profile 16-M1

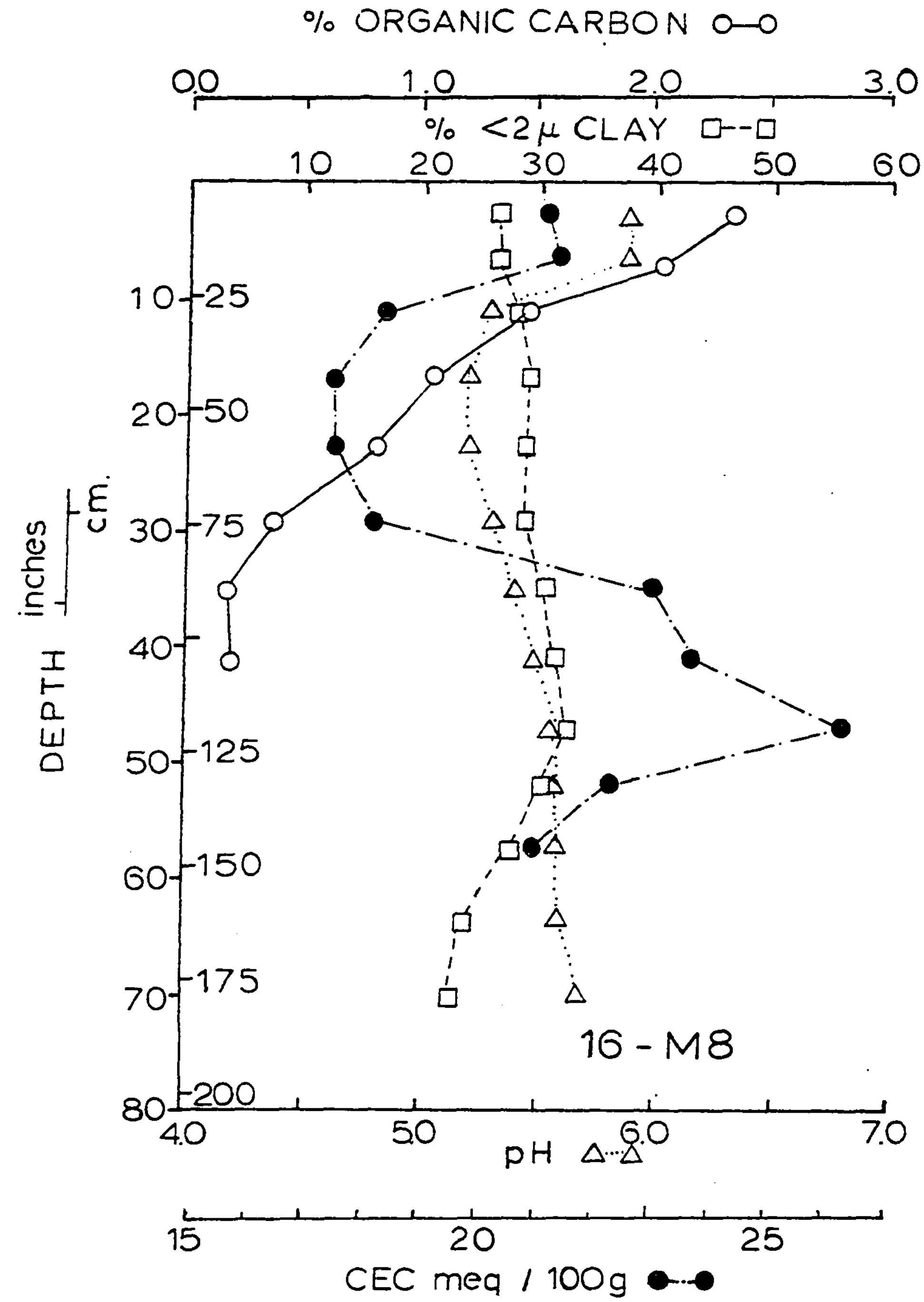


Figure 48. OC, clay, pH, and CEC distribution versus depth for profile 16-M8

inch OC values for the two soils (Table 14). The CEC distribution in the B horizon is attributed to the distribution of the clay.

The CEC distribution in profiles 16-M1 and 16-M8 (Figures 47 and 48) have similar patterns. The response of CEC near the surface of these soils is attributed to the pH dependent charges present. In these profiles the clay maximum occurs at 41 and 47 inches. The CEC distribution shows a marked increase at these depths.

The data presented suggest that pH values must be considered in the evaluation of the interaction of clay and OC effect on exchange capacity. A valid interpretation of the parameters influencing the CEC distribution in the A horizons of Mollisols must include pH dependent charges, OC, and clay.

In the B horizon the CEC can be primarily attributed to the amount of fine clay present. One method of evaluating the representative Tama soils and soils of soil groups No. 1, 2, and 3 in terms of CEC is to consider the weighted CEC values of the B horizon. It was previously shown that the clay maximum is at a greater depth in the profile and has a lower maximum value for soils in soil groups No. 2 and 3. Then it can be predicted that the weighted CEC values for the 10 to 40-inch zone will be lower than the weighted values for soils in soil group No. 1 and profiles 86-1 and PAL-1. This is the precise case (Table 14).

In the introduction to this section it was noted that the method of summing the exchangeable cations resulted in higher CEC values than did the NaOAc method at pH 7.0. Also, it was previously shown that of all the representative Tama soils the NaOAc method was used to determine CEC only for profile 86-1. In order to evaluate CEC values determined by two different methods a factor may be used to set values on an equal basis. For example, to set the weighted CEC value for profile PAL-1 (Table 14) to equal the weighted CEC value of profile 86-1 would require a conversion factor of 0.863. If this conversion factor was then applied to the weighted CEC values of profiles WZ-1 and GS-4 (Table 14), the weighted CEC values would be 19.6 and 18.7 meq/100 g. It was previously shown that profile WZ-1 is characterized by grainy gray ped coatings in the B horizon and profile GS-4 has sands occurring at a depth of 39 inches below the surface. The converted weighted CEC values for these two profiles do not differ greatly from the CEC values reported for soils in soil groups No. 2 and No. 3 (Table 14).

Another attribute of the fine clay and CEC interaction in B horizons is identified by an analysis of the CEC and < 2 μ clay ratio for each sample horizon. Calculation of the CEC/clay ratio for loess-derived Mollisols in different stages of profile development have been reported (Soil Survey Staff, 1966). These data show that the values for CEC/clay ratio plot a more or less vertical line with profile depth. This is also the case for profile 86-1 (Table 13). However, profiles PAL-1, WZ-1, and all profiles in soil groups No. 1, 2, and 3 have increasing CEC/clay ratio values with increasing profile depth (Table 13; see data for profiles in soil groups No. 1, 2, and 3 in Appendix B). Calculation of the CEC/clay ratio values for loess-derived transitional and forest soils results in increased ratio values with profile depth (Soil Survey Staff, 1966).

Transitional and forest-derived soils are more highly weathered than prairie-derived soils at the same stage of development (Shrader, 1950; Richardson, 1974). Transitional and forest-derived soils are associated with more prominent argillans (clay films and clay skins) in the B horizon than are prairie-derived soils. The presence of argillans in the B horizon is accepted as evidence for clay illuviation (Soil Survey Staff, 1960). In illuvial horizons the dominant percentage of clay is in the fine and superfine fractions, $< 0.2\ \mu$ (Ulrich, 1949; Schafer, 1954). Then it may be likely that transitional and forest-derived soils have a greater quantity of $< 0.2\ \mu$ clay in the B horizon than occurs in the B horizon of prairie-derived soils.

The higher CEC/clay ratio values in the B horizon reported in this dissertation are for profiles characterized by grainy gray ped coatings. These profiles require an evaluation as to whether a greater percentage of fine clay is present in their B horizons than in well drained modal Mollisols from the same geographic area on similar landscapes. These data are not available at this time. However, Arnold and Riecken (1964) and Arnold (1965) concluded that a relict forest influence was responsible for the occurrence of grainy gray ped coatings in soils from east-central and eastern Iowa. As previously stated, forest-derived soils should have a larger quantity of fine and superfine clay in the B horizon. Possibly those soils having a relict forest influence would also have larger amounts of fine and superfine clay. If future research proves this hypothesis to be true the higher CEC/clay ratio values with increasing profile depth can be more precisely evaluated in soil development studies.

A source of exchangeable acidity (EA) for Mollisols is attributed to the presence of organic matter (Richardson, 1974). The results of this study show that the maximum EA values occur in the A horizon for all profiles except the soils in soil group No. 1 and profiles 16-M3 and 16-M18 (Table 14; Figures 26, 29, and 32). These profiles are apparently responding to both higher pH values and presence of organic matter in the surface horizon. As previously stated, the dominant source of CEC in the A horizon is the organic matter. Also, the CEC in A horizons responds rapidly to changes in pH because of the weak acid bond dissociations. Then profiles 16-M21, M34, M3, and M18 have higher EA values in the upper B horizon than in the A horizon because of high pH values in the surface horizon. This relationship can be quantified in terms of correlation coefficients (designated "r values"). Calculation of r values for pH and EA over a depth of 0 to 30 inches in the well and moderately well drained Mollisols is reported in Table 16. The r values are significant at the 5% level for profiles 16-M21 and M34. In addition, the r value for profile 16-M18 is significant at the 1% level. All of these r values are negative. The r value for profile 16-M3 is slightly less than the 5% significance level.

The distribution of EA and OC in these same profiles suggests that a significant relationship may occur between OC and EA (Figures 26, 29, and 32). However, calculations yield r values which are negative for some profiles while other profiles within the same group are positive (Table 16). These r values demonstrate that OC alone does not dominate the EA distribution in the 0 to 30-inch zone.

Available phosphorus

The distribution of available phosphorus, AP1, in Mollisols is closely related to the processes of soil genesis. The parameters on which AP1 are dependent within the B horizon of soil profiles include depth and intensity of leaching of carbonates and the distribution of clay.

The profile distributions plotted in Figure 49 show the relationship between AP1, clay distribution, and the depth and intensity of carbonate removal. Profile PAL-1 (Figure 49) demonstrates two properties. First, as pH increases in the lower B horizon AP1 decreases sharply. Second, the AP1

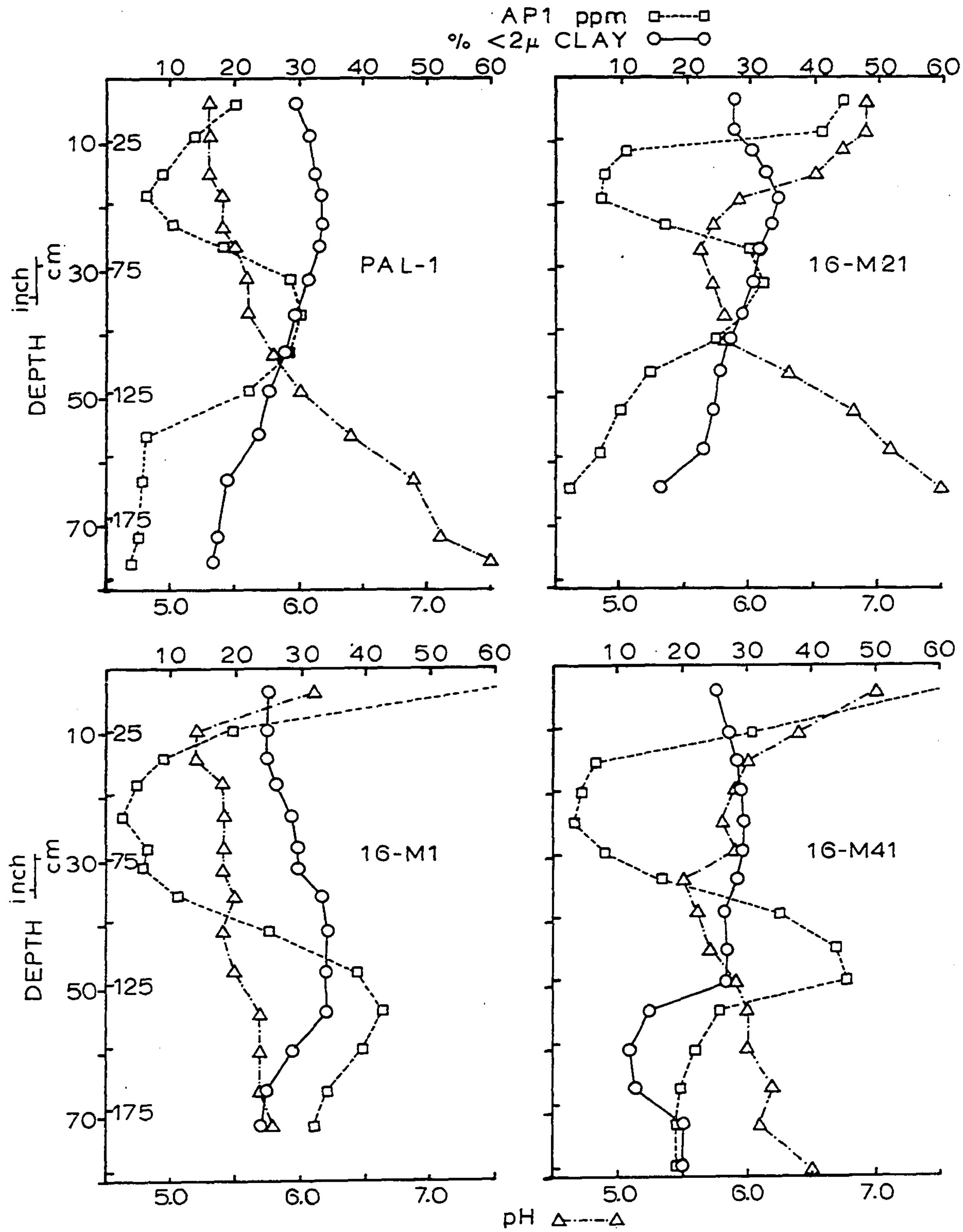
Table 16. Correlation coefficients of EA with pH and OC in the well and moderately well drained Mollisols to a depth of 30 inches

Profile no.	Correlation coefficient	
	EA vs pH	EA vs OC
	Representative Tama soils	
86-1	0.495	0.767*
PAL-1	-0.888**	0.988**
WZ-1	0.585	0.847**
GS-4	-0.689	0.285
	Group No. 1 soils	
16-M21	-0.720*	-0.799*
16-M34	-0.805*	-0.900**
	Group No. 2 soils	
16-M1	-0.373	0.399
16-M3	-0.639	-0.561
16-M6	0.179	0.792*
16-M8	-0.110	0.378
	Group No. 3 soils	
16-M5	0.570	0.986**
16-M18	-0.940**	-0.913**
16-M41	-0.794	-0.384

*Significant at the 5% level.

**Significant at the 1% level.

Figure 49. APl, clay, and pH distribution versus depth for a profile from the representative Tama soils and soil group No. 1, 2, and 3 (data for profile PAL-1 from Fenton, 1966)


AP1 ppm
% <2μ CLAY
10 20 30 40 50 60
PAL-1
16-M21
16-M1
16-M41
DEPTH inch/cm
10-25
30-75
50-125
70-175
5.0 6.0 7.0
pH

maximum occurs below the clay maximum in the lower B horizon. Profile 16-M21 demonstrates similar relationships (Figure 49). Profile 16-M1 demonstrates that the APl maximum in the B horizon occurs at a greater depth below the surface when the clay has been translocated to a greater depth in the lower B horizon (Figure 49). This profile also shows that the maximum APl values are higher in profiles characterized by this type of clay distribution. Profile 16-M41 demonstrates that higher rates of leaching in the solum, which are apparently caused by shallower depths to sands and till, result in an accumulation of APl above the silt-sand and till interface (Figure 49). Also, the APl at this textural interface results in the greatest point accumulation of APl in the B horizon.

The different amounts of APl at different depths in the B horizon and B-C horizon interface is dependent on several parameters. The most obvious parameters include: (1) the depth to the maximum clay content, (2) the distribution of the clay zone in the soil profile, (3) the depth to subjacent sand or till units, and (4) the depth to subjacent carbonates. At pH values above 7.0 the APl is dependent on the solubility of the Ca-phosphates (Smeck, 1973). The solubility of Ca-phosphates decrease with increased pH levels above pH 7.0. At pH values less than 7.0 the APl is dependent on the solubility of the Fe- and Al-phosphates (Smeck, 1973).

The amount and distribution of clay in the soil profile and the depth to increased pH values provide an indication of the intensity and degree of weathering and development which has occurred in a soil profile. These parameters and the distribution of APl in the B horizon have been used to identify the soil series members of biosequences (Tembhare, 1973, p. 190). The B horizons of the prairie-derived soils contained the least amount of APl when compared to transitional and forest-derived soils.

An evaluation of the APl in the subsoil can be assessed by calculating the weighted APl values for the 10 to 40-inch zone and the 10 to 60-inch zone. The ratio between the two weighted zones can then be calculated (Table 17). The resulting ratios indicate that the representative Tama soils have ratios of less than 1.00 and the soils in soil group No. 1 have ratios of less than 1.12. Soils in soil groups No. 2 and No. 3, with the exception of profile 16-M3, have ratios of 1.60 or greater. These data demonstrate that within the lower subsoil, soils in soil groups No. 2 and 3 have: (1) a greater quantity of APl, and (2) a different distribution of APl in comparison to the representative Tama soils and group No. 1 soils (Table 17).

Profile changes across hillslopes

Slopes of less than 2% The changes of univalued profile properties across the hillslope marked by the Bennett transect can be interpreted within a soil-landscape framework. Characteristics of specific profiles can be related to

Table 17. Weighted AP1 values for the well and moderately well drained Mollisols

Profile no.	Weighted AP1 (ppm) 10 to 40 inches	10 to 60 inches	Ratio 10-60/ 10-40
	Representative Tama soils		
PAL-1	17.5	17.3	0.99
WZ-1	21.2	20.3	0.96
	Group No. 1 soils		
16-M21	20.3	17.3	0.85
16-M34	21.9	24.4	1.11
82-M1	17.5	19.6	1.12
	Group No. 2 soils		
16-M1	8.6	20.0	2.33
16-M3	12.9	15.5	1.20
16-M6	8.8	16.9	1.92
16-M8	8.8	15.1	1.72
	Group No. 3 soils		
16-M5	7.5	15.2	2.03
16-M18	13.7	22.4	1.64
16-M41	13.6	22.0	1.62

landscape position along the slope gradient, to the microtopography of the slope, to the influence of vegetation and to the respective drainage class.

For example, the depth to gray mottles can be related to the microrelief of the slope gradient (Figure 36). The change in the ground surface elevation between profile sites 7C through 7K and the depth to gray mottles at each profile are listed in Table 18. The r value for this relationship is 0.87, which is statistically significant at the 1% level. This r value is much higher than data previously reported for similar soil-landscape patterns in eastern Iowa (Walker, Hall, and Protz, 1968).

The slope change and depth to gray mottles between each 100-foot observation can be evaluated in terms of a ratio (Table 18). The ratio for each unit increase or decrease of slope change is accompanied by a unit increase or decrease of depth to gray mottles. The ratio range for profiles 7C through 7I is 1.54 to 2.14 with a mean value of 1.84. One standard deviation for this set of data is ± 0.24.

The profile distribution of more than 0.5% OC is plotted in Figure 36. Profiles 7C, 7E, and 7G have the least amount of OC content with profile depth. The plot (Figure 36) suggests that the OC values for these profiles may be dependent on the microrelief of the slope. This microrelief may influence: (1) sediment removals and accumulations, (2) water regime as to run-in and run-off, (3) native vegetation, and (4) the fertility of the soil.

The microtopography of the ground surface gradient at profiles 7C to 7D, 7D to 7E, and 7G to 7H (Table 18) supports the hypothesis that slope wash may occur at these sites. Smeck and Runge (1972) have implied that if a large amount of rainfall runs off or runs on to an adjacent soil area, the

Table 18. Relationship between ground surface elevation and depth to gray mottles for soils of the Bennett transect

Profile numbers	Change in slope (ft)	Depth to gray mottles (ft)	Ratio mottles/ slope
7C - 7D	1.3	2.67	2.05
7D - 7E	1.2	2.25	1.87
7E - 7F	0.7	1.08	1.54
7F - 7G	0.8	1.50	1.87
7G - 7H	1.3	2.08	1.60
7H - 7I	0.7	1.50	2.14
7I - 7J	0.5	1.16	2.32
7J - 7K	0.6	1.75	2.91

$r = 0.87^{**}$

**Significant at the 1% level.

energy regime of the soils is affected. Increased run-on increases leaching. Increases in the rate of leaching advances weathering processes which will occur due to the decrease in organic coatings on the mineral grains. Therefore, the destabilization of the surface horizons will accelerate profile development.

The morphological characteristics noted in profile 7E suggest that during the development of this profile a vegetative environment other than prairie influenced the profile.

in addition to the morphological characteristics, the thickness of the zone containing more than 0.5% OC is provided as evidence to support this observation. However, in Illinois, Runge (1973) studied prairie - transitional - forest-derived soils which occurred side-by-side on the landscape. His study showed that the transitional and forest-derived soils were less fertile than adjacent prairie-derived soils. He concluded that the soil was responsible for the vegetation and, in turn, the vegetation did not cause the soil. It is evident that the integrated factors of pedogenic and slope processes are actively influencing the development of the profile characteristics of the soils located along this transect.

The integration of pedogenic processes are evident in the available phosphorus distribution of the Bennett transect. Weighted values within the 10 to 40-inch and 10 to 60-inch zone for pH, AP1, and AP2 are listed in Table 19. The extraction of additional Ca-phosphates and the role of high pH values in soil development can be assessed with these data (Table 19). In an acidic environment the AP2 procedure extracts from 1.4 to 1.7 times more phosphorus than does AP1 in the well and somewhat poorly drained soils. Below 40 inches this factor is nearly doubled, or from 2.4 to 2.7 times more phosphorus is extracted with AP2. When the pH increases to provide a near neutral soil environment the AP1 yield decreases by 50% and the AP2 increases by several hundred

Table 19. Weighted pH and available phosphorus distribution in the 10 to 40-inch zone and 10 to 60-inch zone for soils of the Bennett transect

Profile number	10 to 40-inch zone				10 to 60-inch zone			
	pH	AP1 ppm	AP2 ppm	AP2/AP1	pH	AP1 ppm	AP2 ppm	AP2/AP1
M7B	6.1	9.7	12.6	1.30	5.9	12.7	32.1	2.53
M7C	5.7	10.8	16.1	1.49	5.8	14.6	39.5	2.71
M7D	5.8	10.2	15.8	1.54	5.8	16.6	41.3	2.49
M7E	5.7	14.3	21.3	1.48	5.8	16.7	37.8	2.26
M7F	5.8	15.9	27.7	1.74	5.8	17.1	47.1	2.75
M7G	5.8	14.2	20.2	1.42	6.0	15.8	41.8	2.65
M7H	6.6	14.4	22.1	1.54	6.7	20.5	47.9	2.33
M7I	7.1	6.3	45.7	7.26	7.2	5.7	67.4	11.83
M7J	7.1	7.6	42.0	5.52	7.2	6.2	74.8	12.07
M7K	6.6	5.7	28.2	4.94	6.8	4.5	48.4	10.77

percent.

The Ca-phosphates are the major form of phosphorus in the neutral soil environment. The differential in AP2 values for the 10 to 40-inch and 10 to 60-inch zone indicates that the amount of Ca-phosphates present increases with solum depth in both acidic or near neutral soil environments. The increase of Ca-phosphates with profile depth is several times greater in near neutral than acidic soil environments.

Slopes of 6 to 8% The profile characteristics identified in the well and moderately well drained soils across the south flank of the Bennett paha are dependent on the slope gradient. The profile distribution of clay, OC, and AP1 are plotted in Figure 37. These data indicate that parallel hillslope retreat has altered the profile properties. Several dominant processes which occur are: (1) truncation and removal of surface material results in sharp breaks within the plotted distribution of AP1 and OC (Figure 37), (2) soils formed on the lower backslope are subject to influences of fluid gradients which move both vertically and laterally within the parent material and solum, and (3) the properties of the soils located at the footslope and toeslope positions are dominated by cumulic materials and chemical resaturation by soluble cations.

Classification

One objective of the soils investigation was to compare properties of the well and moderately well drained Mollisols in eastern Iowa to representative soils of the Tama series from east-central Iowa. In order to accomplish that objective well and moderately well drained Mollisols from Cedar and Scott counties were partitioned into three soil groups (see Table 16 or 17 for a listing of profiles in each group). The criteria used for defining these groups were primarily the amount and distribution of clay and organic carbon in the sola, matrix colors, and the abundance of grainy gray coats in the B horizon. All of these properties can readily be examined and estimated in a field environment. Other properties investigated included AP1, CEC, pH, and EA.

The clay, AP1, and pH distributions are plotted in Figure 49 for a representative Tama soil and a profile from each of the three soil groups. These profile properties show the basic differences in the soil groups. These differences are:

1. The soils from eastern Iowa have less clay in the surface horizon (Table 14).
2. Soils in soil groups No. 2 and No. 3 have lower clay maximum values in the B horizon. The depth to the clay maximum is greater than 36 inches for soils in soil group No. 2 (Table 14).
3. Soil profiles in soil group No. 2 have a greater

depth to the maximum AP1 value and a greater amount of AP1 at the maximum zone (Table 14).

4. The distribution of AP1 has a point concentration for those profiles that are superjacent to sands or tills if the lithologic interface occurs within 60 inches of the ground surface (Figure 49).

5. The minimum AP1 value in the A3-B1 horizons is lower for soils in soil groups No. 2 and No. 3 (Figure 49).

Other differences in these soil groups included: (1) a greater percentage content and depth distribution of OC for soils in soil groups No. 2 and No. 3 (Figure 43), and (2) lower weighted CEC values in the B horizon for soils in soil groups No. 2 and No. 3 than soils in soil group No. 1 (Table 14).

The final difference between these groups of soils is landscape position and parent materials. All of the soils in soil groups No. 2 and No. 3 are located on the primary divide between the Cedar and Wapsipinicon Rivers. This divide is a broad tabular plain. The landscape indicates little evidence of modification by stream dissection. The microtopography is accentuated by slope gradients of 2% or less. Closed depressions are common. The loess thickness ranges from 12 to 18 feet. Discontinuous sand strata are located between the base of the loess and the truncated till surface. The soils in soil group No. 1 are located on the axis of secondary or tertiary interfluves. The landscape has been modified by stream dissection. Slope gradients range from

1 to 4%. The summits of the interfluves are approaching a convex geometry. Loess thickness ranges from 9 to 15 feet. No sands occur between the base of the loess and the truncated till surface.

The Tama soils are classified as Typic Argiudolls (Soil Survey Staff, 1972). The soils in soil group No. 1 would qualify for this niche in the classification scheme. The soils in soil groups No. 2 and No. 3 do not, in all cases, meet the requirements of an argillic horizon (Table 14). The primary difference between soils in these two groups occurs in the distribution of clay in the profile. Both groups of soils contain lower clay maxima in the B horizon than soils of soil group No. 1 (Table 14). Other physical and chemical properties of soil groups No. 2 and No. 3 are similar, especially when evaluated on a weighted basis (Table 14). The differences between soils in soil groups No. 2 and No. 3 are not sufficient to differentiate the two groups for purposes of soil mapping and taxonomy.

Arnold (1965) proposed that soils similar to those in soil groups No. 2 and No. 3 be classified as Udalfic Hapludolls. This category is presently not recognized in the classification scheme (Soil Survey Staff, 1972).

Soils similar to those recognized in soil groups No. 2 and No. 3 can be recognized in the field on the basis of morphological and physical properties in the sola. Also, these soils occur on a characteristic landscape which can be recognized in the field. The total acreage and areal distribution of these soils extends across parts of at least 12 townships in Cedar and Scott counties. The evidence presented in this dissertation suggests that these soils be recognized as a taxonomic unit separate from Typic Argiudolls.

Soils in soil groups No. 2 and No. 3 meet the criteria of Hapludolls. The pedogenetic evolution concept for these soils includes relict forest influences (Arnold and Riecken, 1964; Arnold, 1965). There is no evidence in this dissertation to dispute that concept. Based on the pedogenetic evolution model proposed by Arnold (1965) these soils cannot qualify for the typic subgroup. The term "thapto" has been introduced as an extragrade subgroup to identify those soils which have properties which are a special departure from the typic subgroup (Soil Survey Staff, 1972). The classification of these soils as Thapto Hapludolls is proposed.

Soils, Landscapes, and Stratigraphy

The basic component of the land surface is a landform. Ruhe (1969a) has defined the landscape as a collection of landforms. In turn, he (Ruhe, 1969a) defines landscapes as three-dimensional units in that they have geographic distribution both in and on material.

Soils are formed on the land surface. They have both width and depth. Therefore, soils are the basic unit of landscapes.

Since soils have depth, by virtue of Jenny's (1941) state factors, soils are related to the underlying stratigraphy of the material on which they form. Then soils can be assessed relative both to the evolution of the landscape and to the underlying materials on which they occur. Ruhe (1969c) has summarized how soils on slopes differ from the soils of the upland-stable surface in relation to the soil-forming factors of time, relief, and parent material.

General soil and landscape relationships do not adequately explain the variations in soils or landscapes within large geographic areas. This fact has been emphasized by others (Fenton, 1966, p. 263). However, constant recurring patterns exist in soil landscapes. These patterns are a function of the state factors defined by Jenny (1941). By investigating these soil patterns, constructing hypotheses for pedogenic and geogenic processes, and testing the hypothesis in the field, it is possible to explain more completely the nature and distribution of soil landscapes.

The final objective of this investigation is to relate soils and soil landscapes to stratigraphic entities. This can be accomplished by two techniques. First, the evidence presented in this dissertation indicates that in the study area the microtopography of the primary divide is related to the presence or absence of sands between the base of the loess and the surface of the truncated till. Where sands occur the absolute highs or swells of the land surface are found. Well and moderately well drained ground soils are formed at these locations. Where sands are absent the intermediate and lows or swales of the landscape are found. Somewhat poorly and poorly drained soils are formed at these locations. Thus, the nature of the stratigraphic column can be predicted at a given point on the land surface. The proposed model for the soil-landscape-stratigraphic relationship of the primary divide is shown in Figure 50.

The second method of relating soils and stratigraphic units is provided by an analysis of the properties of the soils in soil groups No. 1, 2, and 3 (Table 14). All of the soils in soil groups No. 2 and No. 3 occur within the geographic area bound by the primary divided. The soils in soil group No. 1 are formed on the axis of secondary and tertiary interfluves. The differences in the soil properties between soils of group No. 1 and groups No. 2 and No. 3 are of such magnitude that the soils in group No. 1 can be classified as Arguidolls while those soils in the latter two groups can be classified as Hapludolls.

The evidence demonstrates that an evaluation of the landscape alone is not sufficient. The nature of the stratigraphy of the unconsolidated sediments must be understood in order to construct the pedogenic model.

The soil-landscape-stratigraphic model developed in this investigation is not new in Quaternary research. Ruhe (1969a) and his associates and others (Allen, 1971; Vreeken, 1972;

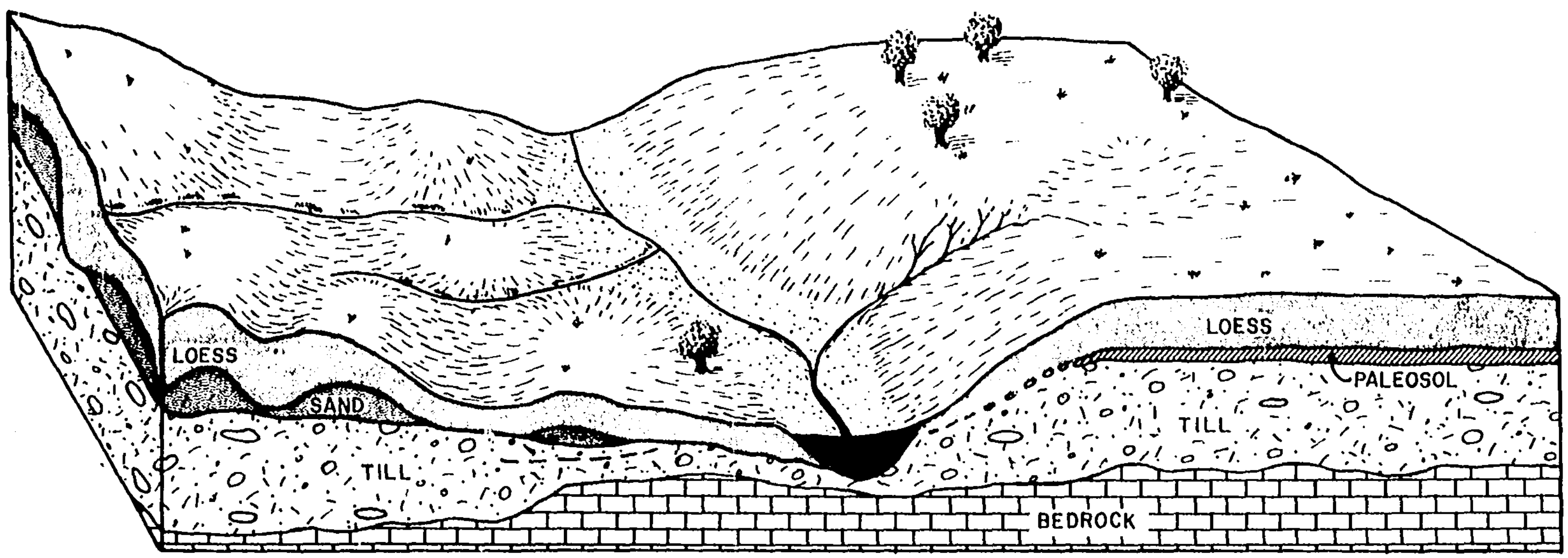


Figure 50. Proposed soil-landscape-stratigraphic model for the geographic area bound by the primary divide in Cedar and Scott counties, Iowa. Area on left represents thick loess-mantled Iowan erosion surface. Area on right represents thick loess-mantled Yarmouth-Sangamon surface

Huddleston and Riecken, 1973) have developed soil-landscape-stratigraphic models for other areas of Iowa. It has been suggested by many Quaternary researchers, including those in soil survey, that a soil-landscape-stratigraphic unit be formulated to categorize repetitive soil occurrences which occur in defined geographic areas. Such a unit would be required to encompass a three-dimensional body which defines the two-dimensional surface and the stratigraphic entity. Most important, the unit must be a mappable feature.

The model for this unit differs from a three-dimensional block diagram constructed for soil association areas (Oschwald et al., 1965) and a Quaternary geology map (Ruhe, 1969a). Both of these models are depicted for large geographic areas. The purpose of this proposed unit is to delineate soil areas which can be differentiated on the state factors of time, topography, and parent material. One state factor does not necessarily have priority over the other two. Examples of such areas which would meet the requirements of this unit would include:

1. The geographic area of the primary divide in Cedar and Scott counties. This area is marked by a bio-hydro-sequence of soils which includes the sequence of soils in soil groups No. 2 and No. 3.
2. The geographic area marked by the bio-hydro-sequence of soils on the Bennett paha.
3. The geographic area including the bio-hydro-sequence of soils in soil group No. 1.

This proposed unit would also be applicable for defining the soils-landscape-stratigraphic areas such as those represented by profile GS-4, a Tama bench phase (Fenton, 1966, p. 110).

This soil-landscape-stratigraphic unit would be an informal designation. That is, the unit would not be subjected to placement in Soil Taxonomy or the Stratigraphic Code. The requirement that this unit be defined for three-dimensional entities excludes morphostratigraphic units (Frye and Willman, 1960) and pedomorphic surfaces (Dan and Yaalon, 1968). Morphostratigraphic units are two-dimensional surface forms and are used as formal units in the Stratigraphic Code (Willman and Frye, 1970). Pedomorphic surfaces are two-dimensional surface forms. The concept of pedomorphic forms (Dan and Yaalon, 1968) includes only the landscape form and the morphological characteristics of the soil horizons.

The term "soil-geomorphic unit" has been proposed (Ruhe, 1974) as a three-dimensional unit which delineates repetitive occurrences of soil patterns. He defines this unit as a time unit as well as a litho-unit. Most important the soil-geomorphic unit is a mapping unit.

A more precise definition of a soil-geomorphic unit is proposed by this author. The soil-geomorphic unit is defined as comprising a body of unconsolidated material which is identified by:

1. A distinct surface form. The surface form encompasses

a set of soils which occur as repetitive patterns across the surface.

2. A distinct sequence of stratigraphic components in the unconsolidated material.
3. A time unit related to the stable, erosional, or constructional portion of the landscape.

In accordance with this definition the geographic area parallel to the Cedar and Wapsipinicon Rivers divide is a soil-geomorphic unit. This unit has slope gradients of 2% or less. The dominant well and moderately well drained soils are prairie-derived, similar in properties to those soils in soil groups No. 2 and No. 3. The soils are formed on a loess-mantled erosion surface which is marked by discontinuous sands between the loess and underlying till. This soil-geomorphic unit is designated the Sunbury unit. Also, the geographic area delineated by the secondary and tertiary interfluves within the thick-loess-mantled Iowan area is a soil-geomorphic unit. This unit has slope gradients of 1 to 5%. The dominant well and moderately well drained soils are prairie-derived, similar in properties to those soils in soil group No. 1. The loess thickness is from 9 to 15 feet. Discontinuous sand strata are absent between the loess and underlying till. This soil-geomorphic unit is designated as the Lime City unit.

Soils, Vegetation, and Climatic History

Climate and vegetation have marked influence on the nature and properties of ground soils. In his analysis of state factors Jenny (1941) showed that climate is actually a function of temperature and moisture. In turn, vegetation is a function of climate. In the study of ground soils the influence of paleoenvironments on soil properties may be made by inference. Inferences can be formulated from select physical and chemical characteristics that can be measured in the modern ground soil. All soil properties derived from the influence of paleoenvironments probably cannot be measured. Only the present soil properties can be measured and evaluated in terms of modern and paleoenvironments. The route of investigation is one of an indirect approach.

In eastern Iowa, Arnold (1965) proposed a soil-landscape model which implies that forest vegetation has had a distinct influence on the nature and properties of the ground soils. These properties are associated with grainy gray ped coatings in the lower B horizon of well and moderately well drained Mollisols. In this dissertation these relict forest features are present in the soil profiles of soil groups No. 2 and 3. As concluded in the preceding section, soils in soil groups No. 2 and 3 are limited to the geographic area delineated by swell-swale topography of the primary divide--the Sunbury soil-geomorphic unit.

The limitation of relict forest features to the Sunbury soil-geomorphic unit requires an evaluation. Several hypotheses include:

1. The Sunbury area was isolated as a forest island in the middle of the prairie region during a portion of the Holocene time.
2. Eastern Iowa was dominated by forest vegetation during a period of the Holocene and forest soil properties were removed by erosion on hillslopes and secondary and tertiary interfluves.

The actual answer may include both hypotheses. The vegetative history of eastern Iowa is based on preliminary pollen diagrams (Ruhe et al., 1968) and the identification of fauna and flora (Kramer, 1972). An on-going investigation by Hallberg[1] and associates suggest that the more recent vegetative history, from 6,200 y.b.p. (years before present) to present, deviates from the regional vegetative pattern which has been proposed (Ruhe et al., 1968, p. 29; Ruhe, 1969a, p. 194). Hallberg proposes the following outlined post-Cary vegetative sequence for eastern Iowa.

1. Dominance of coniferous vegetation until approximately 10,500 y.b.p.
2. Dominance of deciduous vegetation from 10,500 to 8,000 y.b.p.

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[1]Hallberg, G. R., Iowa Geological Survey, Iowa City, Iowa. Correspondence. Personal communication. 1974.

3. During the period of 8,000 to 6,200 y.b.p. the deciduous forest changed to a transitional state and into prairie with the maximum prairie occurring from approximately 7,200 to 6,200 y.b.p. Evidence of this period is found in the Mud Creek sediments on the Cedar-Scott County line. Here Kramer (1972) reported a date of 6,220 y.b.p. from an unconformity at the base of alluvial silts superimposed on sands.
4. Extensive deciduous forests were present on the landscape from 6,200 to 2,800 y.b.p. This may be the period from which the relict forest soil properties are derived and now appear as grainy gray coats in the lower B horizon of prairie-derived soils.
5. The prairie reappeared in eastern Iowa after 2,800 y.b.p. and dominated the landscape until presettlement. During the latter stages of this period forests expanded in valleys adjacent to the uplands (McComb and Loomis, 1944; Loomis and McComb, 1944).

The preceding vegetative sequence suggests that the grainy gray coats in the soils of the Sunbury soil-geomorphic unit are relict from the period of 6,200 to 2,800 y.b.p. If this is proven to be true, then the Mollisols on secondary and tertiary interfluves and associated sideslopes were formed subsequent to 2,800 y.b.p. Furthermore, these Mollisols were formed subsequent to the removal of the dominant forest characteristics in the profile. Walker (1966) concluded that most of the soil features related to Mollisols in central Iowa can be attributed to prairie dominance during the most recent 3,000 years. However, in eastern Iowa evidence for a major erosion cycle has not been conclusively established for the interval subsequent to the maximum arid conditions of the period 7,000 to 6,200 y.b.p. (Kramer, 1972; Vreeken, 1972).

A probable explanation of the lack of grainy gray ped coatings in well and moderately well drained Mollisols on secondary and tertiary interfluves is a combination of surface erosion and pedogenesis. These soils occur on 1 to 4% convex slopes. Rainfall will run-in and run-off. Therefore, the soils are slope dependent. In addition to surface removal of sediment, prairie dominant processes obliterated the remaining relict forest features in the B horizon. In contrast, the soils of the Sunbury soil-geomorphic unit occur on less than 2% slopes. The dominant movement of water on the surface is run-in. Once in the soil water movement is unidirectional. The underlying sands at the base of the loess may increase the vertical movement of water. In these soils the forest-derived properties such as an albic horizon and an argillic zone were translocated downward to the lower B horizon. This process by which the gradual advancement of an albic horizon occurs has been described as profile degradation (Bullock, Milford, and Cline, 1974). This process is dependent on the mobilization of the clay in the upper argillic horizon and the subsequent downward clay movement. The clay is mobilized by rainfall run-in and increased leaching. In the Sunbury area the depth to clay maximum (Table 14) and the nature of the clay distribution (Figures 27 and 30) may be attributed to profile degradation. The modern prairie-derived soils have been superimposed on the relict forest profiles.

The precise explanation of these relict forest features will be answered only by future research in eastern Iowa in the areas of sedimentology, palynology, stratigraphy, geomorphology, paleoclimatology, and pedclogy.

CONCLUSIONS

The results of this study provides a framework from which the parent materials, landscapes, and soils can be evaluated. An evaluation of these parameters were made for the geographic area of east-central Cedar and northwestern Scott counties, Iowa. The models developed from this evaluation are outlined in this section.

Parent Materials, Stratigraphy, and Weathering Zones

The construction of an isolith map for the unconsolidated material demonstrates that broad, tabular flats on primary divides are a function of bedrock. Beneath these areas the absolute elevation of the bedrock is the highest. Also, the thickness of the unconsolidated materials are thinner when compared to adjacent areas.

A thick-loess-mantled erosion surface can be identified in an area which parallels the primary divide between the Cedar and Wapsipinicon Rivers. This area extends from the southern boundary of the previously defined Iowan erosion surface, in northern Cedar County, to the area marked by the Cleona channel in southeastern Cedar and western Scott counties. This delineation encompasses approximately 105,000 acres of land surface. The erosion surface is characterized by a loess-mantle ranging from 9 to 18 feet in thickness. The base of the loess is marked by discontinuous sand dunes superjacent to a truncated till surface. These discontinuous sand dunes are confined to the primary divide. No evidence of sand was found at the base of the loess on secondary or tertiary interfluves. This area is designated the thick-loess-mantled Iowan erosion surface.

Radiocarbon dates were collected from coreholes in the Bennett paha. This paha abuts the thick loess-mantled Iowan erosion surface. The dates show that in this area the Iowan erosion surface was cut between 21,150 and 17,810 years before present. Therefore, in the Bennett and Sunbury Flat area the thick loess deposits on the Iowan erosion surface are younger than 17,810 years.

The present definition of oxidation states in loessial weathering zones implies a chemical state of iron oxide. An unoxidized zone in loess is actually a reduced or deoxidized zone in terms of the chemical state of iron. The concept of unoxidized loess is unacceptable in terms of the chemical states of iron. A new set of terms, "brunambric", "pallic", and "glaucic", are proposed to describe color zonations in loessial weathering zones.

Available phosphorus (AP1) analysis of the loessial weathering zone provides a qualitative measurement of maximum and minimum phosphorus transformations. AP1 distribution reveals a maximum amount of phosphorus transformation in the lower solum and subjacent oxidized and leached zone. In the unleached zone AP1 is not effective in identifying phosphorus transformations.

The available phosphorus (AP2) distribution provides a qualitative measurement of a large quantity of transformed phosphorus in the zone subjacent to the solum. In the deoxidized and unoxidized and unleached zones, AP2 distribution suggests that phosphorus transformations occur in the weathering profile.

Soils

The morphological, chemical, and physical properties of the well and moderately well drained soils provided a framework for partitioning these soil profiles into three soil groups. The properties of each of these soil groups were compared to representative Tama soils from east-central Iowa. The soils in soil groups No. 2 and No. 3 generally had similar properties. The soils in soil groups No. 2 and No. 3 were compared to soils in soil group No. 1 and the representative Tama soils. The major property differences for soil groups No. 2 and No. 3 include:

1. A lower clay maximum and greater depth to the clay maximum in the profile.
2. No argillic horizon in the upper B horizon. Some exceptions do occur.
3. A higher maximum AP1 value in the subsoil and a greater depth in the profile to this higher AP1 value.
4. Higher weighted OC values from 0 to 15 inches.
5. Lower weighted CEC values in the 10 to 40-inch zone.
6. Location of these soils on swells along the primary

divide. Maximum slope gradients are 2%.

7. Abundant grainy gray ped coatings in the 26 to 34-inch zone.

The proposed classification for soils in soil groups No. 2 and No. 3 is Thapto Hapludolls. Soils in soil group No. 1 qualify for the Tama series, Typic Argiudolls.

Soil Landscapes

The microtopography of the primary divide is related to the presence or absence of sands between the base of the loess and the surface of the truncated till. Sands are associated with ground surface swells and well and moderately well drained soils. The absence of sands is associated with intermediate slopes and swales on the ground surface. These landscapes represent the somewhat poorly and poorly drained soils.

Within a limited geographic area, soil-landscape-stratigraphic models can be formulated. These models represent repetitive occurrences of soils that differ from abutting soil geographic areas by the factors of time, topography, and parent material. The term soil-geomorphic unit is proposed as a three-dimensional unit which can be used to map soil-landscape-stratigraphic entities. A soil-geomorphic unit is identified by: (1) a distinct surface form, (2) a distinct sequence of stratigraphic components, (3) a repetitive occurrence of soils, and (4) a time unit related to the stable, erosional, or constructional portion of the landscape.

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APPENDIX A: PROFILE DESCRIPTIONS

This appendix contains a listing of abbreviations used in describing soil materials and a detailed description of each profile. Profiles are listed in a chronological order. Standard descriptive nomenclature as outlined by the Soil Survey Staff (1951) is used in this appendix. The Munsell notations are for moist colors. Principal colors are given for the crushed matrix unless denoted as kneaded. Weathering zone terminology is defined as outlined by Fenton (1966, p. 282).

Abbreviations used in descriptions are as follows:

abund	abundant
arg	argillans
band	band(s)
bdy	boundary
bly	blocky
brk	breaking to
BWP	Basal Wisconsin paleosol
c	clear
ch	channel(s)
cl	clay loam
co	coarse
com	common
conc	concretions
cont	continuous
ct	coatings(s)
D	deoxidized
dec	decrease
disc	discontinuous
dk	dark
ext	exterior
Fe	iron
fi	fine
fri	friable
g	gradual
gr	granular
gry	gray grainy
gty	gritty
hvy	heavy
inc	increase
inter	intercalated
knd	kneaded
l	loam
L	leached
ls	loamy sand
lt	light
m	many
M	mottled
mass	massive
med	medium
mix	mixing
mm	millimeter
Mn	manganese
mod	moderate
mot	mottles
O	oxidized
occ	occasional
org	organic
pl	platy
pr	prismatic
s	sandy or sand(s)
sbk	subangular blocky
scl	sandy clay loam
segr	segregation
si	silt
sic	silty clay
sil	silt loam
sicl	silty clay loam
sl	sandy loam
str	strong
surf	surface
thk	thick
trun	truncated
U	unoxidized (as first symbol) unleached (as second symbol)
v	very
vert	vertical
w	with
wk	weak
YSP	Yarmouth-Sangamon paleosol

Site: 16-M1
Drainage: moderately well
Slope: 1%
Elevation: 798.0
Location: 790 ft. N., 290 ft. E. of SW cor. NW¼ sec. 22, T.80N., R.1W.

Depth (inches)	Horizon or zone	Description
0-7	A11	10YR 2/1 hvy sil; mod fi gr; fri; pH 6.1; g bdy
7-12	A12	10YR 2/1 w ext ct 10YR 3/1 & 10YR 2/2 hvy sil; wk fi gr to wk fi sbk; fri; pH 5.2; c bdy
12-16	A13	10YR 3/2 w mix 10YR 4/3 hvy sil; wk fi sbk; fri; pH 5.2; c bdy
16-20	B1	10YR 3/2 ext ct 10YR 4/2 hvy sil; wk fi sbk; fri; pH 5.4; c bdy
20-26	B21	10YR 4/3 ext ct 10YR 4/4 lt sicl; few fi 2.5Y 5/2 mot; wk fi pr brk mod fi sbk; fri; few thin disc gry ct on ped ext; pH 5.4; c bdy
26-33	B22	10YR 4/4 ext 2.5Y 5/2, knd 2.5Y 5/4 sicl; com fi 7.5YR 4/4, 10YR 5/6 & 2.5 YR 2/2 mot; wk fi pr brk mod med sbk; fri m cont gry ct on ped ext; m Mm conc 2.5YR 2/2; pH 5.4; g bdy
33-38	B23	10YR 5/4 ext ct 5Y 5/2, knd 10YR 5/4 sicl; com med 5YR 4/6 & com fi 7.5YR 4/4, 10YR 4/2, & 2.5YR 2/2 mot; mod fi pr; fri; m cont gry ct on ped ct; m Mn con 2.5YR 2/2; pH 5.5; c bdy
38-51	B24	2.5Y 5/2 to 5Y 5/3 sicl; m fi 7.5YR 4/4 mot; mod fi pr; fri; flows 10YR 4/2 on ped ext; m co Mn conc 2.5YR 4/2; pH 5.4 g bdy
51-57	B31	10YR 5/4 sicl; m fi 10YR 5/3 & m med 2.5Y 5/2 mot; wk med pr; fri; com Mn conc 2.5YR 2/2, 2 to 3 mm; pH 5.7; g bdy

Depth (inches)	Horizon or zone	Description
57-79	MOL	10YR 5/3 to 5/4 hvy sil; com fi 7.5YR 4/4 & 10YR 5/6; m fi 2.5Y 5/2 mot; com Mn conc 2.5YR 2/2; loess
79-93	MOL	10YR 4/3 sil; com fi 7.5YR 4/4 & 2.5Y 5/2 mot; few Mn conc 2.5YR 2/2, 1 to 2 mm; loess
93-117	MOL	2.5Y 5/4 lt sil; few fi 7.5YR 5/6, com fi 5Y 5/1, & m med 7.5YR 4/4 mot; com Mn conc 2.5YR 2/2; loess
117-148	MOU	2.5Y 5/4 to 5Y 5/3 si; m fi 10YR 5/6, 5Y 5/2, & 7.5YR 4/4 mot; com Mn conc 2.5YR 2/2; loess
148-149	MOU	Band 2.5Y 3/2, 10YR 5/6, & 2.5Y 5/2 si; loess
149-168	MOU	2.5Y 5/4 to 4/4 si to sil w depth; com med 7.5YR 4/4, 2.5Y 5/3, 5Y 5/2, 5Y 5/1 mot; fi Mn conc 2.5YR 2/2; loess
168-175	MOU	2.5Y 5/4 to 10YR 5/4 sil; com med 5YR 3/2 & 5Y 5/2 mot; fi Mn conc 2.5YR 2/2; inter sands and silts
175-202	O&U	2.5Y 5/3 sl to ls; sands

Site; 16-M3
Drainage: well
Slope: 2%
Elevation: 799.0
Location: 745 ft. N., 830 ft. W. of SW cor. sec 22, T.80N., R.1W.

0-9	Ap	10YR 2/1 sil; wk fi pl; fri; pH 6.4; g bdy
9-14	A12	10YR 2/2 w mix 10YR 3/2 lt sicl; wk fi gr; fri; pH 6.1; g bdy
14-18	A13	10YR 3/3 ext ct 10YR 2/2 lt sicl; mod med gr brk wk fi sbk; fri; pH 5.6; g bdy

Depth (inches)	Horizon or zone	Description
18-27	B21	10YR 4/3 to 4/4 ext ct 10YR 3/4 lt sicl; mod fi sbk; fri; few Mn conc 2.5YR 2/2; pH 5.6; g bdy
27-32	B22	10YR 5/3 ext ct 10YR 4/4 lt sicl; mod med sbk; fri; few Mn conc; pH 5.6; g bdy
32-41	B23	10YR 5/4 ext ct 5Y 5/3 sicl; com fi 7.5YR 4/4 mot; wk med pr; fri; com disc gry ct on ped ext; com Mn conc 2.5YR 2/2; pH 5.7; g bdy
41-54	B31	2.5Y 5/4 ext 2.5Y 5/2 to 5Y 5/2 lt sicl; com fi 7.5YR 5/6 mot; mod med pr; fri; m Mn conc 2.5YR 2/2; pH 5.8; c bdy
54-61	B32	2.5Y 5/4 ext 5Y 5/3 hvy sil; com med 10YR 5/6 mot; wk fi pr; fri; com Mn conc 2.5YR 2/2; pH 5.9; c bdy
61-121	MOL	10YR 5/4 to 2.5Y 5/4 w depth sil; com fi 7.5YR 4/4, 5Y 5/2, & 10YR 5/6 mot; com Mn conc 2.5YR 2/2; loess
121-122	MOL	Band 10YR 3/2, 10YR 5/6, & 2.5Y 5/4 sil; com Mn conc 2.5YR 2/2; loess
122-130	O&U	5Y 5/3 to 2.5Y 5/4 w depth sil; few Mn conc 2.5YR 2/2; loess
130-186	O&U	10YR 5/4 to 2.5Y 5/4 l & sl; sands
186-200	MDL	5Y 5/2 cl; com fi 7.5YR 4/4, 10YR 5/6 & 5Y 4/1; till

Site: 16-M4
Drainage: somewhat poorly
Slope: <1%
Elevation: 794.0
Location: 165 ft. N., 870 ft. W. of SE cor. sec. 22, T.80N., R.1W.

0-7	Ap	10YR 2/1 lt sicl; wk fi gr brk to wk fi pl; fri; pH 6.4; c bdy
7-13	A21	10YR 3/1 w mix 10YR 2/1 & 4/1 hvy sil; wk fi pl; fri; pH 5.7; c bdy

Depth (inches)	Horizon or zone	Description
13-17	A22	10YR 4/1 lt sil; com fi 2.5YR 3/2, 10YR 3/1, & 10YR 2/1 mot; mod fi pl; fri; pH 5.3; c bdy
17-23	B1	10YR 5/2 sil; com fi 2.5YR 3/2, 10YR 4/1, & 10YR 3/1; mod fi pl; fri; pH 5.3; c bdy
23-30	B21	2.5Y 5/2 sicl; com fi 2.5YR 3/4 to 3/6 & 10YR 4/1 to 3/1 mot; mod fi pr brk mod fi sbk; fri; pH 5.0; c bdy
30-38	B22	2.5Y 5/2 to 5Y 5/2 sicl; m fi 5YR 4/6 & m com 10YR 3/1 mot; mod fi pr brk mod fi sbk; fri; pH 5.1; c bdy
38-45	B23	5Y 5/2 lt sicl; com fi 5YR 4/6 & com med 10YR 4/1 mot; wk fi pr; fri; pH 5.2; c bdy
45-51	B3	5Y 5/2 lt sicl; few fi 7.5YR 4/4 & com med 10YR 4/1 mot; wk fi sbk; dk gray ct on ped ext; pH 5.3; g bdy
51-128	MDL	5Y 5/2 sil; few fi 10YR 4/2, com fi 7.5 YR 4/4, 10YR 5/6, & 2.5Y 5/4 mot; loess
128-145	MDL	5Y 5/1 hvy si; m med 5Y 5/3 & com fi 10YR 5/6 & 2.5Y 5/4 mot; loess
134-165	MOL	5Y 5/3 to 2.5Y 5/4 cl; com fi 10YR 5/6 & 7.5YR 4/4 mot; till

Site: 16-M5
Drainge: well
Slope: 2%
Elevation: 802.0
Location: 110 ft. S., 80 ft. E. of NW cor. of NE¼SE¼SE¼ sec. 23, T.80N., R.1W.

0-6	Ap	10YR 2/1 to 2/2 hvy sil; wk fi gr brk wk fi pl; fri; pH 5.6; a bdy
6-10	A12	10YR 2/2 hvy sil; wk fi pl brk to wk fi sbk; fri; pH 5.5; c bdy

Depth (inches)	Horizon or zone	Description
10-16	A13	10YR 3/2 w mix 10YR 3/3 lt sicl; wk fi sbk; fri; pH 5.5; c bdy
16-23	B1	10YR 3/3 lt sicl; wk fi sbk; fri; ct of 10YR 3/4; pH 5.6; c bdy
23-27	B21	10YR 5/3 sicl; mod med sbk; fri; few gry ct on ped ext of 10YR 7/1; pH 5.4; c bdy
27-32	B22	10YR 5/4 lt sicl; mod med sbk; fri; com gry ct on ped ext; pH 5.4; c bdy
32-40	B23	10YR 5/4 lt sicl; m med 10YR 5/6 & 7.5YR 4/4 mot; mod med sbk brk to mod med pr; fri; m gry ct on ped ext; pH 5.6; c bdy
40-49	B3	10YR 5/4 lt sicl; com med 10YR 5/3 & 7.5YR 4/4 mot; wk med sbk; com gry ct on ped ext; com Mn conc; pH 5.6; g bdy
49-120	MOL	10YR 5/4 sil; m med 7.5YR 4/4, 2.5YR 3/2, 10Y 6/3, 7.5YR 4/4, 10YR 5/6 mot; com Mn conc; loess
120-140	MOU	10YR 5/4 to 2.5Y 5/4 l sil; com med 10YR 5/6 & 2.5Y 6/2 mot; com Mn conc; loess
140-160	MOL	10YR 5/6 s cl; com med 5YR 4/3, 7.5YR 4/4, & 10YR 5/3 mot; till

Site: 16-M6
Drainage: well
Slope: 2%
Elevation: 804.0
Location: 475 ft. S., 25 ft. E. of NW cor. of NE¼SE¼SE¼ sec. 23, T.80N., R.1W.

0-7	Ap	10YR 2/1 lt sicl; wk fi gr brk wk fi pl; fri; pH 5.8; a bdy
7-11	A12	10YR 2/2 lt sicl; wk fi sbk; fri; pH 5.8; c bdy
11-15	A13	10YR 2/2 sicl; wk fi sbk; fri; disc ct, 10YR 3/2 on ped ext; pH 5.6; g bdy

Depth (inches)	Horizon or zone	Description
15-21	A14	10YR 3/3 w mix 4/3 sicl; mod fi sbk; fri; pH 5.3; c bdy
21-30	B21	10YR 4/3 w mix 5/3 sicl; mod fi sbk; fri; few Mn conc; pH 5.6; c bdy
30-35	B22	10YR 5/3 sicl; com fi 10YR 5/2 & 7.5YR 4/4 mot; mod med sbk; fri; few disc gry ct on ped ext; few Mn conc; pH 5.5; c bdy
35-47	B23	10YR 5/3 sicl; m fi 7.5YR 4/4, 5YR 4/6, & 2.5Y 5/2 mot; wk med pr; fri; m cont gry cts on ped ext; com Mn conc; pH 5.6; g bdy
47-58	B3	10YR 5/3 sicl to hvy sil w depth; m med 5YR 4/6, 7.5YR 4/4, 2.5Y 5/2 mot; wk med pr brk wk med sbk; flows 10YR 2/2 along pore ch; m Mn conc; pH 5.7; g bdy
58-113	MOL	10YR 5/3 sil; com fi 7.5YR 4/4 & 2.5Y 5/2 mot; com Mn conc; loess
113-140	MOU	10YR 5/4 hvy si; com fi 10YR 5/6 mot; few Mn conc; loess
140-148	MOU	2.5Y 5/4 sil to loam; inter sands & silt
148-179	MOU	2.5Y 5/6 to 10YR 5/6 l to sl; sands

Site: 16-M7A
Drainage: well
Slope: 1%
Elevation: 803.8
Location: 179 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	A11	10YR 2/2 hvy sil; wk fi gr; fri; pH 7.3; c bdy
8-11	A12	10YR 2/2 w mix 10YR 3/2 hvy sil; mod fi gr; fri; pH 7.4; a bdy
11-14	A13	10YR 3/2 lt sicl; mod fi gr to wk fi sbk; fri; disc 10YR 2/2 org ct on ped ext; pH 6.7; c bdy

Depth (inches)	Horizon or zone	Description
14-19	A14	10YR 3/3 sicl; mod fi sbk; fri; disc 10YR 3/2 org cts on ped ext; few disc gry ct; pH 6.1; c bdy
19-23	B21	10YR 5/4 ext ct 10YR 4/3 sicl; mod fi sbk; fri; disc gry ct; pH 5.8; c bdy
23-29	B22	10YR 5/4 ext ct 10YR 4/4 sicl; few fi 10YR 6/3 mot; mod med sbk; fri; cont gry ct; pH 5.8; a bdy
29-35	B23	10YR 5/4 ext co 2.5Y 5/2 sicl; m med 2.5Y 5/2, 10YR 5/6, 7.5YR 5/6, 5YR 3/3 mot; mod co sbk brk mod med pr; fri; cont gry ct; m co Mn conc; pH 5.7; c bdy
35-41	B24	10YR 5/4 ext ct 2.5Y 5/2 sicl; m med 7.5YR 5/6 mot; mod co pr brk mod med sbk; fri; cont gry ct; m co Mn conc 2.5YR 2/2; pH 5.7; c bdy
41-44	B31	10YR 5/4 ext ct 2.5Y 5/2 sicl; m med 5Y 5/2 & 10YR 5/6 mot; mod med pr brk mod med sbk; fri; disc gry ct; m co Mn conc 2.5YR 2/2; pH 5.9; c bdy
44-50	B32	10YR 5/4 sil; com co 10YR 5/6 & 5Y 5/2 mot; wk med sbk; fri; ct 10YR 3/2 on root channels; com med Mn; pH 6.1; g bdy
50-88	MOL	10YR 5/4 sil; com co 10YR 5/6 & 5Y 5/2 mot; com Mn conc; loess
88-121	MOU	10YR 5/4 lt sil; m med & co 10YR 5/6, 7.5YR 5/8, & 5Y 5/2 mot; m Mn conc; loess
121-150	MOU	5Y 5/3 to 5Y 5/2 w depth lt sil; com med & co 10YR 5/6, 2.5Y 5/4, & 5YR 4/8 mot; com Mn conc; loess
150-154	O&U	5YR 4/8 sil; fe band; loess
154-210	O&U	10YR 5/6 sl to ls; sands
210-215	D&L	5Y 5/1 to 4/1 cl; till

Site: 16-M7B
Drainage: well
Slope: 1%
Elevation: 803.7
Location: 280 ft. N., 385 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

Depth (inches)	Horizon or zone	Description
0-6	Ap	10YR 2/2 hvy sil; wk fi gr; fri; pH 6.7; c bdy
6-10	A12	10YR 3/2 lt sicl; wk fi sbk; fri; pH 6.4; c bdy
10-15	A13	10YR 3/2 to 3/3 lt sicl; mod med sbk; fri; pH 6.3; c bdy
15-21	B1	10YR 3/3 sicl; mod med sbk; fri; pH 6.1; c bdy
21-26	B21	10YR 5/4 ext ct 10YR 5/2 sicl; mod med sbk; fri; disc gry ct; pH 5.8; c bdy
26-34	B22	10YR 5/4 ext ct 10YR 5/2 sicl; com med 10YR 5/6 mot; mod med sbk; fri; pH 5.7; c bdy
34-42	B23	10YR 5/4 sicl; com med 10YR 5/6 & 2.5Y 5/2 mot; wk med sbk; fri; pH 5.7; g bdy
42-60	B31	10YR 5/4 lt sicl to sil w depth; com med 10YR 5/6 & 2.5Y 5/2; wk med sbk to mass w depth; fri; pH 5.7

Site: 16-M7C
Drainage: moderately well
Slope: 1%
Elevation: 803.3
Location: 310 ft. N., 485 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-9	Ap	10YR 2/2 sil; wk fi gr; fri; pH 6.8; c bdy
9-13	A12	10YR 3/2 w mix 10YR 3/3 hvy sil; mod fine sbk; fri; pH 6.8; c bdy

Depth (inches)	Horizon or zone	Description
13-15	A13	10YR 3/2 to 3/3 sicl; mod fi sbk; fri; pH 5.9; c bdy
15-20	B1	10YR 4/3 sicl; mod med sbk; fri; pH 5.6; c bdy
20-27	B21	10YR 5/4 sicl; mod med sbk; fri; cont gry coats; pH 5.6; c bdy
27-32	B22	10YR 5/4 sicl; com fi 10YR 5/6 & 5/2 mot; mod med sbk; fri; disc gry coats 10YR 4/3; pH 5.7; c bdy
32-40	B23	10YR 5/4 sicl; com fi 2.5Y 5/2 & 10YR 5/6 mot; wk med sbk; pH 5.7; c bdy
40-60	B3	10YR 5/4 to 2.5Y 5/4 sicl to sil w depth; com fi 10YR & 2.5Y 5/2 mot; wk med sbk to mass; pH 6.0

Site: 16-M7D
Drainage: somewhat poorly
Slope: 1%
Elevation: 802.0
Location: 322 ft. N., 585 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/2 sil; wk fi gr; fri; pH 7.1; c bdy
8-13	A12	10YR 2/2 to 3/2 hvy sil; mod med gr brk wk fi sbk; fri; pH 7.0; g bdy
13-15	A13	10YR 2/2 to 3/2 lt sicl; med fi sbk; fri; pH 6.2; g bdy
15-27	B21	10YR 4/2 ext ct 10YR 3/2 sicl; few fi 10YR 5/6 & few med 10YR 4/3 mot; mod med sbk; fri; pH 5.8; g bdy
27-31	B22	10YR 4/2 w mix 10YR 5/4 sicl; com fi 10YR 5/6 & 10YR 3/1 mot; mod med sbk; fri; pH 5.7; c bdy
31-40	B23	2.5Y 5/4 sicl; com med 10YR 5/6 & 2.5Y 5/2 mot; mod med sbk; fri; pH 5.6; g bdy

Depth (inches)	Horizon or zone	Description
40-52	B3	2.5Y 5/4 lt sicl to hvy sil w depth; com med 10YR 5/6 & 2.5Y 5/2 mot; wk med sbk; fri; pH 5.7; g bdy
52-60	MOL	5Y 5/3 sil; few co 7.5YR 4/4 & 10YR 5/6; Fe & co Mn conc; loess

Site: 16-M7E
Drainage: somewhat poorly
Slope: 1%
Elevation: 800.8
Location: 335 ft. N., 680 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/2 sil; wk fi gr; fri; pH 6.8; c bdy
8-13	A2	10YR 4/2 to 2.5Y 4/2 lt sicl; wk fi sbk brk to wk fi pl; fri; pH 6.6; c bdy
13-18	B1	2.5Y 5/2 sicl; few fi 10YR 5/6 mot; mod fi sbk; fri; pH 5.7; g bdy
18-22	B21	2.5Y 5/2 sicl; m med 10YR 5/6 mot; mod med sbk; fri; pH 5.6; g bdy
22-39	B22	2.5Y 5/2 sicl; com med 10YR 5/8 mot; mod med pr brk mod med bly; fri; pH 5.6; g bdy
39-46	B3	5Y 5/3 sicl; com med 10YR 5/6 mot; wk med sbk; fri; pH 5.8; g bdy
46-60	MOL	2.5Y 5/2 sil; com med 5Y 5/1 & few fi 10YR 5/6 mot; loess

Site: 16-M7F
Drainage: somewhat poorly
Slope: 1%
Elevation: 800.1
Location: 380 ft. N., 770 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/2 sil; wk fi gr; fri; pH 7.2; c bdy

Depth (inches)	Horizon or zone	Description
8-12	A12	10YR 3/1 hvy sil; mod fi gr; fri; pH 7.1; c bdy
12-18	A13	10YR 3/1 hvy sil; few fi 10YR 5/2 mot; mod fi sbk; fri; pH 6.0; c bdy
18-25	B1	10YR 4/3 sicl; com fi 2.5Y 5/2, 10YR 5/6 & com co 10YR 4/2 mot; mod med sbk; fri; pH 5.6; c bdy
25-40	B2	2.5Y 5/2 sicl; com med 10YR 5/6 & few fi 2.5Y 2/2 mot; mod med bly brk mod med sbk; fri; pH 5.6; g bdy
40-45	B3	2.5Y 5/2 lt sicl; mot same as above; wk med pr brk wk med sbk; fri; ct 10YR 3/1 along pore walls; pH 5.7; c bdy
45-60	MDL	2.5Y 5/2 lt sicl to sil w depth; mot same as above; loess

Site: 16-M7G
Drainage: somewhat poorly
Slope: 1%
Elevation: 799.3
Location: 435 ft. N., 755 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/1 to 3/1 sil; wk fi gr; fri; pH 7.1; a bdy
8-11	A12	10YR 3/3 w mix 10YR 4/2 hvy sil; mod fi gr; fri; pH 6.9; c bdy
11-19	B1	10YR 4/2 lt sicl; mod fi sbk; fri; pH 5.8; c bdy
19-25	B21	10YR 4/2 sicl; com fi 10YR 5/6 mot; mod fi sbk; fri; pH 5.7; c bdy
25-38	B22	2.5Y 5/2 sicl; com med 10YR 5/6 & few fi 2.5YR 2/2 mot; mod med pr brk mod med bly; fri; pH 5.7; c bdy
38-60	B3	2.5Y 5/2 lt sicl; mot same as above; wk mod bly to mass w depth; pH 6.3

Site: 16-M7H
Drainage: poorly
Slope: < 1%
Elevation: 798.0
Location: 490 ft. N., 840 ft. E. of SW cor NW¼NW¼ sec. 13, T.80N., R.1W.

Depth (inches)	Horizon or zone	Description
0-7	Ap	10YR 2/1 lt sicl; wk fi gr; fri; pH 7.1; a bdy
7-12	A12	10YR 2/2 to 3/1 lt sicl; mod fi gr; fri; pH 7.1; c bdy
12-18	A3	10YR 3/1 sicl; mod med sbk brk mod med gr; few fi 10YR 3/2 mot; fri; pH 6.7; c bdy
18-27	B1	10YR 4/1 sicl; com fi 10YR 5/6 & 2.5Y 5/2 mot; mod med pr brk to mod med sbk; fri; pH 6.5; c bdy
27-35	B2	2.5Y 5/2 sicl; com fi 2.5Y 5/4 & 10YR 4/1 mot; mod med pr brk mod med sbk; fri; pH 6.4; c bdy
35-42	B3	5Y 5/2 lt sicl; com med 10YR 5/6 mot; mod med pr brk mod med sbk; fri; pH 6.8; c bdy
42-60	MDL	5Y 5/2 lt sicl; com med 2.5Y 5/2 mot; loess

Site: 16-M7I
Drainage: poorly
Slope: 1%
Elevation: 797.4
Location: 540 ft. N., 1020 ft. E. of SW cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/1 sicl; wk fi gr; fri; pH 7.1; a bdy
8-14	A12	10YR 2/1 sicl; mod fi gr to mod fi sbk; fri; pH 7.1; c bdy

Depth (inches)	Horizon or zone	Description
14-23	B1	10YR 4/1 hvy sicl; com fi 10YR 3/1, 10YR 4/2, & 2.5Y 5/4 mot; mod fi sbk; fri; pH 7.0; c bdy
23-29	B2	2.5Y 4/2 to 5/2 sicl; few fi 10YR 5/6 & 4/1 mot; mod med pr brk mod med bly; fri; pH 7.0; c bdy
29-39	B3	2.5Y 5/2 sicl; few fi 10YR 5/6 mot; mod med pr to mod med bly; fri; pH 7.1: g bdy
39-54	MDL	2.5Y 5/2 sil; few med 10YR 5/6 mot; loess
54-128	MDL	5Y 5/2 sil; m med 10YR 5/6 & 7.5YR 4/4 mot; loess
128-156	D&U	5Y 5/2 to 4/2 sil; few co 7.5YR 4/4, 10 YR 5/6, & 2.5Y 5/4 mot; loess
156-166	MDL	5Y 5/3 l; com med 2.5Y 5/4 mot; till
166-188	MOL	2.5Y 5/4 hvy l; com co 5Y 5/2 mot; till

Site: 16-M7J
Drainage: poorly
Slope: < 1%
Elevation: 798.4
Location: 715 ft. S., 215 ft. W. of NE cor $NW\frac{1}{4}NW\frac{1}{4}$ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 2/1 sicl; wk fi gr; fri; pH 6.7; a bdy
8-21	A12	10YR 2/1 sicl; mod fi gr to wk fi sbk; fri; pH 6.9; c bdy
21-28	B21	10YR 3/1 sicl; few fi 10YR 3/2 mot; mod med sbk; fri; pH 7.0; c bdy
28-38	B22	2.5Y 5/2 lt sicl; com fi 2.5Y 5/4 & few fi 10YR 5/6 mot; mod med sbk; fri; pH 7.2; g bdy
38-50	B3	2.5Y 5/2 hvy sil; few med 10YR 3/1 mot; wk med sbk; fri; pH 7.4; g bdy

Depth (inches)	Horizon or zone	Description
50-60	MDL	5Y 5/2 hvy sil; few med 10YR 5/6 mot; loess

Site: 16-M7K
Drainage: poorly
Slope: < 1%
Elevation: 798.8
Location: 670 ft. S., 135 ft. W. of NE cor NW¼NW¼ sec. 13, T.80N., R.1W.

0-7	Ap	10YR 2/2 to 3/1 sil; wk fi gr; fri; pH 7.1; a bdy
7-11	A12	10YR 2/2 sil; mod fi gr; fri; pH 6.7; a bdy
11-12	IIA11b	10YR 2/1 w mix 10YR 2/2 sil; wk fi pl; fri; pH 6.4; a bdy
12-20	IIIA11b	N 2/0 sicl; mod med gr; fri; pH 6.1; c bdy
20-24	IIIA12b	10YR 3/1 hvy sicl; few fi 10YR 3/2; mod med sbk; fri; pH 6.3; c bdy
24-28	IIIB21b	2.5Y 4/2 hvy sicl; mod med sbk; com fi 2.5Y 5/2 & few fi 2.5Y 5/4 mot; mod med sbk; fri; pH 6.5; c bdy
28-41	IIIB22b	5Y 5/3 sicl; com med 10YR 5/6, 2.5Y 5/4 & 2.5Y 4/2 mot; mod med sbk; fri; pH 7.1; c bdy
41-45	IIIB3b	5Y 5/2 hvy sil; com med 10YR 5/6 & few fi 2.5Y 4/2 mot; wk med sbk; fri; pH 7.3

Site: 16-M8
Drainage: well
Slope: 1%
Elevation: 803.0
Location: 50 ft. N., 1300 ft. W. of SE cor NE¼ sec. 24, T.80N., R.1W.

0-5	Ap	10YR 2/2 hvy sil; mod fi gr; fr; pH 5.9; a bdy

Depth (inches)	Horizon or zone	Description
5-8	A12	10YR 2/2 hvy sil; wk fi sbk; fri; pH 5.9; c bdy
8-14	A13	10YR 3/2 lt sicl; mod fi sbk; fri; pH 5.3; c bdy
14-20	A3	10YR 3/2 w mix 10YR 5/4 sicl; mod med sbk; fri; pH 5.2; c bdy
20-26	B1	10YR 3/2 w mix 10YR 5/4 sicl; mod med sbk; fri; few Mn conc; pH 5.2; g bdy
26-33	B21	10YR 4/3 w mix 10YR 5/4 & 5/6 sicl; mod fine sbk; fri; m fi Mn conc; pH 5.3; c bdy
33-38	B22	10YR 5/4 w mix 10YR 5/6 sicl; mod med sbk; fri; m fi Mn conc; disc gry ct 10YR 7/2 on ped ext; m fi Mn conc 2.5YR 2/2; pH 5.4; c bdy
38-45	B23	10YR 5/4 sicl; com fi 10YR 5/6 & 7.5YR 4/6 mot; mod fi sbk; fri; disc gry ct 10YR 6/2 on ped ext; pH 5.5; c bdy
45-50	B24	10YR 5/4 sicl; m fi 10YR 5/6, 7.5YR 4/4, 5Y 5/3 mot; mod med pr; fri; cont gry ct 10YR 5/2 on ped ext; com co Mn conc 2.5YR 2/2; pH 5.6; c bdy
50-55	B31	10YR 5/4 sicl; mot as above; mod med pr; disc gry ct 10YR 5/2 on ped ext; com med Mn conc; few co Fe segr; fri; pH 5.6; c bdy
55-68	B32	2.5Y 5/4 lt sicl to sil with depth; com med 10YR 5/6 mot; wk med sbk; fri; few Mn conc; Fe stains of 5YR 5/8; pH 5.6; g bdy
68-130	MOL	10YR 5/4 to 2.5Y 5/4 sil; m med 10YR 5/6 & 5Y 5/3 mot; m Mn conc; loess
130-162	MOU	2.5Y 5/4 lt sil; com med 2.5Y 5/6, 5Y 5/2, 5Y 5/3, & 10YR 5/6 mot; m Mn conc; loess

Depth (inches)	Horizon or zone	Description
162-225	C&U	10YR 5/4 to 5/4 l to sl to ls w depth; si band at 180 & 185 in; sands
225-240	D&L	5Y 4/1 to 4/2 cl; till

Site: 16-M9
Drainage: somewhat poorly
Slope: 1%
Elevation: 762.0
Location: 70 ft. N., 580 ft. E. of SW cor. SW$\frac{1}{4}$ sec. 13, T.79N., R.1W.

0-11	Ap	10YR 2/2 sil; mod fi gr; fri; pH 5.6; a bdy
11-15	A3	10YR 3/3 w mix 10YR 3/2 sil; wk fi sbk; fri; pH 5.1; c bdy
15-22	B1	10YR 4/3 w mix 10YR 5/4 sicl; wk fi sbk; fri; com med Mn conc; pH 5.1; c bdy
22-25	B21	2.5Y 5/2 sicl; com med 7.5YR 5/6 mot; mod fi sbk; disc gry ct on ped ext; com Mn conc; pH 5.1; c bdy
25-31	B22	10YR 5/4 sicl; com med 10YR 5/6 mot; mod fi sbk; fri; cont gry ct 2.5Y 5/2; few disc arg; few Mn conc; pH 5.1; c bdy
31-41	B23	10YR 5/4 sicl; m med 10YR 5/6 & few fi 7.5YR 4/4 mot; mod fi pr; disc gry ct 5Y 5/3; few med Mn conc; pH 5.0; g bdy
41-55	B24	10YR 5/4 sicl; m med 10YR 5/6 & 5Y 5/3 mot; wk to mod med pr; arg flows along root ch; com med Mn conc; pH 5.6; a bdy
55-102	MOL	10YR 5/4 sil; m med 10YR 5/6 & 5Y 5/3; Mn conc at 76 to 78 in; loess
102-121	MOU	Same as above
121-154	O&U	10YR 5/6 ls; si band at 138, 140, 145, 151, 154 in; sands

Depth (inches)	Horizon or zone	Description
154-188	O&L	10YR 5/6 ls; si band 2.5Y 5/2 at 169-176" & 182-188"; sands
188-226	D&U	2.5Y 6/2 to 5Y 5/2 sil; Mn conc 222 to 226; loess
226-278	MOL	10YR 5/6 to 5/8 l; com med 5YR 3/4; till

Site: 16-M10
Drainage: somewhat poorly
Slope: 1%
Elevation: 779.0
Location: 35 ft. N., 125 ft. W. of SE cor. NW¼ sec 2, T.79N., R.1W.

0-49	Solum	
49-82	MOL	Loess
82-152	MOU	Loess
152-202	O&U	Sands
202-228	MOL	Till
228-230	MOU	Till

Site: 16-M11
Drainage: moderately well to somewhat poorly
Slope: <1%
Elevation: 841.0
Location: 475 ft. N., 465 ft. E. of SW cor. NE¼ sec. 25, T.81N., R.2W.

0-44	Solum	
44-82	MOL	Loess
82-198	MOU	Loess
198-302	O&U	Sands
302-336	D&U	Sands
336-350	MOL	Till

Site: 16-M12
Drainage: well
Slope: 1%
Elevation: 856.0
Location: 122 ft. S., 48 ft. E. of NW cor SE¼SE¼ sec. 11, T.81N., R.2W.

Depth (inches)	Horizon or zone	Description
0-51	Solum	
51-102	MOL	Loess
102-154	MOU	Loess
154-215	O&L	Sands
215-241	MOL	Till
241-270	MOU	Till

Site: 16-M13
Drainage: Poorly
Slope: <1%
Elevation: 794.0
Location: 87 ft. S., 83 ft. W. of NW cor. sec 26, T.80N., R.1W.

0-35	Solum	
35-96	D&L	Loess
96-170	MOL	Till

Site: 16-M14
Drainage: poorly
Slope: <1%
Elevation: 795.5
Location: 81 ft. S., 126 ft. W. of NW cor. sec 26, T.80N., R.1W.

0-42	Solum	
42-110	D&L	Loess
110-130	D&U	Loess

Depth (inches)	Horizon or zone	Description
130-136	O&L	Sands
136-187	MOL	Till
187-190	MOU	Till
190		Limestone

Site: M15
Drainage: somewhat poorly
Slope: <1%
Elevation: 830.9
Location: 520 ft. N., 380 ft. W. of SE cor. SW$\frac{1}{4}$ sec 12, T.80N., R.1W.

0-8	Ap	10YR 3/1 sil; wk fi gr; fri; pH 5.9; a bdy
8-11	A2	10YR 4/2 sil; wk fi pl; fri; pH 5.4; c bdy
11-16	B1	10YR 3/1 lt sicl; mod fi sbk; disc gry ct on ped ext; com Mn conc; pH 5.3; c bdy
16-23	B21	10YR 4/3 to 5/4 sicl; few fi 10YR 5/6 mot; wk fi pr brk mod fi sbk; fri; cont gry ped ct; few Mn conc; pH 5.2; c bdy
23-28	B22	2.5Y 5/2 sicl; com fi 10YR 5/6 & few fi 7.5YR 4/4 mot; wk med pr brk mod med sbk; fri; cont gry ped ct; abund grains on ct; few Mn conc; pH 5.3; g bdy
28-39	B23	2.5Y 5/4 sicl; com med 10YR 5/6 mot; mod med pr; fri; thk cont gry ped ct w abund grains on ct; m Mn conc; pH 5.3 g bdy
39-44	B24	5Y 5/3 sicl; m med 10YR 5/6 mot; wk med pr; fri; disc gry ped ct; org ct 10YR 3/1 along ch; pH 5.5; c bdy
44-56	B3	2.5Y 5/4 sicl; com med 5Y 5/3, 2.5Y 3/2, & 10YR 5/6 mot; wk med pr to mass; fri; disc gry ped ct; org ct 10YR 3/1 along ch; pH 5.6; c bdy

Depth (inches)	Horizon or zone	Description
56-97	MOL	10YR 5/4 knd sil; com med 5Y 5/3, 2.5Y 3/2, & 10YR 5/6 mot; loess
97-112	MCU	10YR 5/6 knd lt sil; m co 5Y 5/2 mot; loess
112-127	D&U	5Y 5/2 lt sil; fi bands 10YR 5/6 & 2.5Y 5/4 @ 119-121"; loess
127-155	O&U	10YR 5/6 to 2.5Y 5/4 lt sil; few bands 5Y 5/2; loess
155-176	D&U	2.5Y 5/2 lt sil; loess
176-180	DMU	5Y 5/2 lt sil; bands of 7.5YR 4/4 mot; loess
180-241	U&U	5Y 4/1 to 5/1 w depth lt sil; loess
241-280	U&U	5GY 5/1 lt sil to si; loess
280-290	U&U	5Y 4/1 hvy sil; loess
290-302	IIA1b	2.5Y 4/2 to 10YR 4/2 hvy sil; charcoal flecks; mass; BWP
302-309	IIC1b	5Y 4/1 lt sil; BWP
309-316	IIIA21b	5Y 4/1 sil; m fine 5Y 7/1 mot; mass; YSP
316-323	IIIA22b	5Y 4/2 hvy sil; mass; YSP
323-329	IIIA23b	5Y 6/2 lt sicl; m fi 10YR 2/1 mot; str fi pl; YSP
329-334	IIIB1b	5Y 5/3 sicl; 10YR 2/1 mot; str fi pl; YSP
334-337	IIIB21b	5Y 3/1 to 3/2 sic; few fi 5Y 7/1 & few co 2.5Y 4/2 mot; med fi pl; YSP
337-341	IVB21b	2.5Y 3/2 sic; few med 2.5Y 5/4 & 5Y 3/1 mot; mass; YSP
341-352	IVB22b	5GY 4/1 & 5G 4/1 hy sicl; com fi 5Y 3/1 mot; mass; YSP
342-367	IVB23b	5GY 5/1 to 5Y 5/1 sicl; m med 2.5Y 4/4 & 5Y 5/1 mot; YSP

Site: 16-M16
Drainage: well
Slope: 2%
Elevation: 781.0
Location: 450 ft. N., 96 ft. W. of SE cor. SW¼ sec. 31, T.80N., R.1W.

Depth (inches)	Horizon or zone	Description
0-51	Solum	
51-135	MOL	Loess
132-160	O&U	Intercalated silts & sands
160-249	O&U	Sands
249-278	MOL	Till

Site: 16M17
Drainage: somewhat poorly
Slope: <1%
Elevation: 776.0
Location: 268 ft. N., 468 ft. W. of SE cor. SW¼ sec 31, T.80N., R.1W.

0-42	Solum	
42-130	MOL	Loess
130-164	MOU	Loess
164-206	MOU	Sand
206-209	MOL	Till

Site: 16-M18
Drainage: well
Slope: 2%
Elevation: 860.0
Location: 835 ft. N., 50 ft. E. of SW cor. SE¼ sec 28, T.82N., R.2W.

0-10	Ap	10YR 2/1 sil; wk med sbk; fri; pH 7.1; c bdy

Depth (inches)	Horizon or zone	Description
10-14	A12	10YR 2/1 to 2/2 sil; mod fi sbk; fri; fri; few disc gry ct; pH 7.1; c bdy
14-19	A13	10YR 2/2 hvy sil; wk fi sbk; fri; few disc gry ct; pH 6.9; g bdy
19-23	A14	10YR 3/3 lt sicl; wk fi sbk; fri; few disc gry ct; pH 6.9; g bdy
23-29	B1	10YR 3/3 to 4/3 w ext ct 10YR 3/2 lt sicl; wk to mod fi sbk; fri; disc gry ct; few Mn conc; pH 6.4; c bdy
39-39	B2	10YR 4/4 w ext ct 10YR 3/3 lt sicl; mod med sbk; cont gry ct; com Mn conc; pH 5.7; c bdy
39-47	B3	10YR 5/6 w ext ct 10YR 5/3 sil; mod med pr brk wk med sbk; fri; cont gry ct; m Mn conc; pH 5.9; c bdy
47-56	MOL	10YR 5/4 w ext ct sil; few fi 5Y 5/4 mot; loess
56-57	D&L	7.5YR 4/4 lt sl; intercalated sand
57-72	MOL	10YR 5/4 sil; few fi 10YR 5/6 mot & 2.5 YR 2/2 Mn conc; loess
72-99	O&L	10YR 5/4 to 2.5Y 5/4 sl to s; inter si @ 75-79" & 85-87"
99-109	O&L	10YR 5/4 l to ls; inter sands and silts
109-127	O&L	10YR 5/6 hvy loam; few med 2.5Y 5/4 mot; till
127-147	O&U	10YR 5/6 l; few med 2.5Y 5/4; till

Site: 16-M19
Drainage: well
Slope: 1%
Elevation: 894.0
Location: 550 ft. S., 110 ft. E. of NW cor. NW¼ sec. 12, T.81N., R.2W.

0-46	Solum	

Depth (inches)	Horizon or zone	Description
46-97	MOL	Loess
97-132	MOU	Loess
132-164	D&U	Loess
164-226	MOU	Loess
226-242	D&U	Loess
242-322	U&U	Loess
322-329	IIA1b	BWP
329-356	IIC1b	BWP
356-370	Paleo-solum	YSP

Site: 16-M20
Drainage: well
Slope: 2%
Elevation: 834.0
Location: 485 ft. N., 112 ft. E. of SE cor., NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 30, T.81N., R.2W.

0-51	Solum	
51-145	MOL	Loess
145-168	MOU	Loess
168-173	O&L	Sand
173-206	D&U	Loess
206-283	O&U	Sand

Site: 16-M21
Drainage: well
Slope: 1%
Elevation: 806.0
Location: 55 ft. S., 46 ft. E. of NW cor. SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 10, T.80N., R.2W.

Depth (inches)	Horizon or zone	Description
0-7	Ap	10YR 2/2 lt sicl; wk fi gr; fri; pH 6.9; c bdy
7-10	A12	10YR 2/1 to 2/2 w mix 10YR 3/2 lt sicl; wk fi gr; fri; pH 6.9; c bdy
10-13	A13	10YR 2/2 w mix 10YR 3/2 sicl; wk fi sbk; fri; pH 6.7; c bdy
13-17	B1	10YR 3/2 w mix 10YR 2/2 sicl; wk fi sbk; fri; pH 6.5; c bdy
17-21	B21	10YR 4/3 sicl; wk med sbk; fri; pH 5.9; c bdy
21-29	B22	10YR 4/3 to 5/4 sicl; wk med sbk; fri; few Mn conc; pH 5.7; c bdy
29-35	B23	10YR 5/4 sicl; wk med sbk; fri; few disc cts; pH 5.6; c bdy
35-43	B3	10YR 5/4 lt sicl; wk med sbk; fri; few disc 10YR 5/3 to 5/2 cts on vert ch; pH 5.8; c bdy
43-61	MOL	10YR 5/4 knd sil; com med 10YR 5/6, 10YR 5/2 mot & 2.5YR 2/2 Mn conc; loess
61-166	O&U	10YR 5/4 knd lt sil; few med 10YR 5/6, 5Y 5/2 mot & 2.5YR Mn conc; loess
166-183	U&U	5Y 4/1 to 5GY 4/1 sil; loess
183-214	O&L	10YR 5/6 to 5/8 hvy l; till
214-231	O&U	2.5Y 5/4 hvy l; till

Site: 16-M22
Drainage: well
Slope: 3%
Elevation: 804.0
Location: 315 ft. N., 195 ft. E. of SW cor. NW¼SE¼ sec. 31, T.80N., R.2W.

0-43	Solum

Depth (inches)	Horizon or zone	Description
43-69	O&L	Loess
69-70	O&L	Sand
70-79	O&L	Loess
79-113	O&L	Sand
113-139	O&L	Loess w intercalated sand
139-162	O&L	Loess
162-235	O&U	Loess
235-310	U&U	Loess
310-318	IIAlb	BWP
318-336	IIClb	BWP
336-349	Paleo-solum	YSP

Site: 16-M23
Drainage: somewhat poorly
Slope: 3%
Elevation: 840.0
Location: 16 ft. S., 1131 ft. E. of NW cor. SW¼SE¼ sec. 12, T.82N., R.3W.

0-33	Solum	Loess
33-67	MOL	Till
67-120	O&U	Till

Site: 16-M24
Drainage: somewhat poorly
Slope: <1%
Elevation: 45 ft. S., 700 ft. W. of NE cor. SE¼SW¼ sec. 12, T.79N., R.2W.

0-8	Ap	10YR 2/1 sil; mod fi gr; fri; pH 6.1; c bdy

Depth (inches)	Horizon or zone	Description
8-11	A12	10YR 3/1 knd, mix 10YR 2/1, 3/1, & 3/2 sil; wk fi gr; fri; com disc gry ct; pH 6.1; c bdy
11-14	A13	10YR 3/2 knd, mix 10YR 3/2 & 4/2 hvy sil; wk fi sbk; fri; com disc gry ct; pH 5.7; c bdy
14-17	B1	10YR w mix 10YR 3/2, 4/3, & 5/3 lt sicl; med fi sbk; fri; disc arg & gry ct; pH 5.5; c bdy
17-21	B21	10YR 4/3 knd w mix 10YR 4/2, 5/3, & 5/4 sicl; mod med sbk; fri; disc arg & gry ct; pH 5.4; c bdy
21-28	B22	10YR 5/2 hvy sicl; few med 10YR 5/4 & 5/6 mot; str med sbk; fri; cont arg & gry ped ct; com Mn conc of 2.5YR 2/2; pH 5.3; c bdy
28-36	B23	10YR 5/2 hvy sicl; com med 10YR 5/4 & 5/6 mot; mod med pr brk mod med sbk; fri; disc arg & cont gry ped ct; abund Mn conc of 2.5YR 2/2; pH 5.5; c bdy
36-41	B24	10YR 5/2 sicl; m med 10YR 5/6 mot; mod med pr brk mod med sbk; fri; disc arg & gry ped ct; abund Mn conc of 2.5YR 2/2; pH 5.9; c bdy
41-48	B31	10YR 5/2 sicl; m med 10YR 5/6 mot; wk med sbk; fri; disc arg; ct of 10YR 3/1 along vert ch; abund Mn conc 2.5YR 2/2; pH 5.9; c bdy
48-56	B32	2.5Y 5/4 knd lt sicl; m med 10YR 5/6 & few co 7.5YR 4/6 mot; wk mod sbk; fri; few disc arg; abund Mn conc of 2.5YR 2/2; pH 6.1; c bdy
56-92	MOL	10YR 5/4 knd sil; abund med 7.5YR 4/6, 10YR 5/6, & 5Y 5/2 mot; loess
92-146	MOU	5Y 5/3 sil to lt sil; m co 10YR 5/6, 7.5YR 4/6, few co 5YR 5/8 mot; com Mn conc of 2.5YR 2/2; loess

Depth (inches)	Horizon or zone	Description
146-152	D&U	5Y 5/2 lt sil; few v fi 10YR 5/6 & 5/4 mot; loess
152-170	MOU	10YR 5/6 to 2.5Y 5/4 lt sil; com fi 5Y 5/2 & 2.5Y 5/2 mot; conc Mn band, 2.5YR 2/2 from 168-170"; loess
170-268	U&U	5GY 5/1 to 5Y 4/1 lt sil; loess
268-285	U&U	5Y 4/1 si; loess
285-289	IIA1b	5Y 4/2 sil; mass; leached; BWP
289-297	IIC1b	5Y 4/1 to 5GY 5/1 si; mass; leached; BWP
297-310	IIIA11b	5GY 4/1 lt sicl; com med 5Y 7/1 mot; mass; YSP
310-318	IIIA12b	5GY 4/1 sicl; com med 5Y 7/1 mot; mass; YSP
318-326	IIIA13b	5GY 4/1 hvy sicl; mass; YSP
326-332	IIIB1b	5GY 5/1 sic; mod fi pl; YSP

Site: 16-M26
Drainage: well
Slope: 6%
Elevation: 825.0
Location: 63 ft. S., 119 ft. W. of NE cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-8	Ap	10YR 3/1 to 3/2 hvy sil; wk fi gr; fri; pH 7.3; a bdy
8-12	A12	10YR 3/3 sicl; wk v fi sbk; fri; pH 7.0; c bdy
12-15	B1	10YR 4/3 w ext ct 10YR 3/3 sicl; wk fi sbk; fri; few disc gry ped ct 10YR 7/1; pH 6.9; c bdy
15-18	B21	10YR 5/4 w ext ct 10YR 4/3 sicl; mod fi sbk; fri; few disc gry ped ct 10YR 7/1; few Mn conc; pH 6.8; c bdy

Depth (inches)	Horizon or zone	Description
18-21	B22	10YR 5/4 w ext ct 10YR 4/3 sicl; mod med sbk; fri; com disc gry ped ct 10YR 6/3; few Mn conc; pH 6.6; c bdy
21-26	B23	10YR 5/4 sicl; few med 10YR 5/6 mot; mod med pr brk mod co sbk; fri; com disc gry ped ct 10YR 6/3; com Mn conc 2.5YR 2/2; pH 6.5; g bdy
26-34	B24	10YR 5/4 sicl; com med 10YR 5/6 mot; mod med pr brk to mod co sbk; com cont gry ped ct 10YR 7/1; m Mn conc 2.5YR 2/2; pH 5.8; c bdy
34-44	B31	10YR 5/4 sicl; m med 10YR 4/2, 5/2, & 5/6 mot; mod med pr brk mod med sbk; disc gry ped ct 10YR 7/1; m Mn conc 2.5YR 2/2; pH 6.0, c bdy
44-50	B32	10YR 5/4 lt sicl; m med 10YR 4/2, 5/2, & 5/6 mot; wk med sbk; few disc gry ped ct 10YR 7/1; m Mn conc 2.5YR 2/2; g bdy
50-102	MOL	10YR 5/4 knd sil; m med 10YR 5/6 & 2.5Y 5/4 mot; abund Mn conc 2.5YR 2/2; loess
102-126	O&U	10YR 5/4 to 5/6 hvy sil to l; few co 5Y 6/3 mot; loess w inter sand 106-107"
126-150	O&L	10YR 5/6 sl; slightly unleached in lower increment; sands
150-169	O&U	10YR 5/4 to 5Y 5/3 l to sil; loess
169-178	O&U	7.5YR 5/8 to 5Y 6/3 sl; sands
178-193	O&U	2.5Y 5/4 & 6/3 sil; loess
193-198	U&U	5Y 4/1 sil; plant micro-fossils; loess
198-272	U&U	5Y 4/1 to 5GY 4/1 sil to si; segr 5Y 2/1; loess
272-278	IIAlb	5GY 4/1 hvy sil; OC flecks N 2/0; mass; BWP

Depth (inches)	Horizon or zone	Description
278-282	IIIA1b	5GY 4/1 lt sicl; OC flecks N 2/0; few 5Y 8/1 mot; mass; YSP
282-290	IIIA21b	5Y 5/1 to 5GY 4/1 sicl; few 5Y 8/1 mot; mass; YSP
290-294	IIIA22b	5Y 4/1 to 5GY 4/1 sicl; few 5Y 6/1 mot; mass; YSP
294-298	IIIB1b	5BG 4/1 lt sic; YSP

Site: 16-M27
Drainage: well
Slope: 7%
Elevation: 818.0
Location: 163 ft. S., 118 ft. W. of NE cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-6	Ap	10YR 3/2 lt sicl; wk fi sbk; fri; pH 6.8; c bdy
6-8	A12	10YR 3/2 w mix 10YR 4/3 lt sicl; mod fi sbk; fri; pH 6.9; c bdy
8-11	A13	10YR 3/3 w mix 10YR 4/3 lt sicl; mod fi sbk; fri; pH 6.8; c bdy
11-16	B21	10YR 5/4 sicl; com fi 10YR 5/2 mot; mod fi sbk; fri; few Mn conc; pH 6.6; c bdy
16-26	B22	10YR 5/4 sicl; m med 10YR 5/2 mot; wk med pr brk wk med sbk; com disc gry ped ct; m Mn conc 2.5YR 2/2; pH 5.9; c bdy
26-30	B23	10YR 5/4 sicl; same as above; pH 5.8; c bdy
30-36	B3	10YR 5/4 hvy sil; same as above; pH 5.9; g bdy
36-117	MOL	10YR 5/4 sil; m med 10YR 5/2 & 5Y 5/3 mot; inter sand: 98-100", 108-109", 116-117"; loess
117-142	O&U	Loess, inter sands at 142"

Depth (inches)	Horizon or zone	Description
142-152	O&U	Bands of 5Y 5/1; loess
152-172	D&U	Loess
172-214	U&U	Loess
214-221	BSP	Loess
221-236	Paleo-solum	YSP

Site: 16-M28
Drainage: moderately well
Slope: 6%
Elevation: 811.3
Location: 263 ft. S., 118 ft. W. of NE cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-6	Ap	10YR 3/2 w ext ct 10YR 2/2 hvy sil; med fi gr; fri; pH 7.2; a bdy
6-8	A12	10YR 3/3 w ct 10YR 3/2 hvy sil; wk fi sbk; fri; pH 7.1; a bdy
8-11	A13	10YR 3/3 to 4/3 lt sicl; wk fi sbk; fri; pH 6.8; c bdy
11-15	B1	10YR 4/3 w ext ct 10YR 3/3 sicl; wk fi sbk; fri; few Mn conc 2.5YR 2/2; pH 6.6; g bdy
15-19	B21	10YR 4/3 sicl; mod fi sbk; fri; few disc gry ped ct; few Mn conc 2.5YR 2/2; pH 6.4; c bdy
19-23	B22	10YR 5/4 w ext ct 10YR 4/3 sicl; few fi 10YR 5/6 & 2.5Y 5/2 mot; wk med pr brk mod med sbk; cont gry ped ct; com Mn conc 2.5YR 2/2; pH 5.8; c bdy
23-32	B23	10YR 5/4 sicl; com fi 10YR 5/6 & 2.5Y 5/2 mot; wk med pr; fri; cont gry ped ct; m Mn conc 2.5YR 2/2; pH 5.6; c bdy

Depth (inches)	Horizon or zone	Description
32-55	B24	10YR 5/4 sicl; com med 10YR 5/6, 2.5Y 5/2, & 7.5YR 4/4 mot; wk med pr brk wk med sbk; fri; cont gry ped ct along vert ch; disc on other ped ext; m Mn conc 2.5YR 2/2; pH 5.7; c bdy
35-41	B3	10YR 5/4 to 5/6 lt sicl; mot as above; wk med sbk; fri; ct as above; m Mn conc 2.5YR 2/2; pH 5.6; g bdy
41-120	MOL	10YR 5/4 to 5/6 hvy sil to sil w depth; mot as above, dec w depth; m Mn conc 2.5YR 2/2; loess
120-160	MOU	2.5Y 5/4 lt sil; com fi 2.5Y 5/2 mot; inter sand @ 120-122"; loess
160-171	O&U	2.5Y 5/4 l; inter sands & silts
171-236	O&U	2.5Y 5/6; sands
236-254	D&U	5Y 5/2 sil; loess
254-264	U&U	5Y 4/1 sil; loess
264-267	IIA1b	5Y 4/1 to 5GY 4/1 sil; charcoal flecks N 2/0; mass; BWP
267-270	IIIB31b	5Y 4/1 & 5GY 4/1 sicl; m fi 5Y 4/4 mot; mass; trun YSP
270-275	IIIB32b	5Y 4/3 hvy sicl; m fi 5Y 4/4 mot; wk med sbk; trun YSP
275-284	IIIB33b	5Y 4/3 hvy sicl; m fi 2.5Y 5/4 & 5Y 4/2 mot; wk med sbk; trun YSP
284-304	O&L	10YR 5/6 to 5/8 cl; till

Site: 16-M29
Drainage: well
Slope: 8%
Elevation: 814.6
Location: 213 ft. S., 118 ft. W. of NE cor. NW¼NW¼ sec. 13, T.80N., R.1W.

Depth (inches)	Horizon or zone	Description
0-6	Ap	10YR 3/2 w mix 3/3 lt sicl; wk fi gr; fr fri; pH 6.9; a bdy
6-9	A12	10YR 3/3 w mix 3/2 lt sicl; wk fi sbk; fri; pH 6.7; g bdy
9-13	B21	10YR 5/4 sicl; wk fi sbk; fri; few disc gry ped ct; pH 6.5; c bdy
13-26	B22	10YR 5/4 sicl; com med 10YR 5/2 & 5/6 mot; mod med pr brk wk med sbk; fri; com cont gry ped ct; few Mn conc 2.5YR 2/2; pH 6.1; c bdy
26-32	B23	10YR 5/4 lt sicl; abund med 10YR 5/2, 5/3, & 5/6 mot; wk med pr brk wk med sbk; fri; disc gry ped ct; com Mn conc 2.5YR 2/2; pH 5.7; c bdy
32-43	B3	10YR 5/4 to 5/6 hvy sil; mot as above; wk med sbk; fri; some disc org ct along vert ch; abund Mn conc 2.5YR 2/2; pH 5.9; g bdy
43-86	MOL	10YR 5/6 sil; abund med 10YR 5/2, 5/3, & 5/4 mot; m Mn conc 2.5YR 2/2; loess
86-92	O&L	10YR 5/6 sl; sands
92-119	O&L	10YR 5/6 l; abund med 10YR 5/4 & 2.5Y 5/2 mot; few Mn conc 2.5YR 2/2; inter silts & sands
119-129	O&L	10YR 5/6 sl; sands
129-133	MOL	10YR 5/6 sil; com med 2.5Y 6/2 & 5/4; band Mn conc 2.5YR 2/2 @ 132-133"; loess
133-147	MOU	10YR 5/6 to 2.5Y 5/4 w depth sil; abund fi 2.5Y 6/2 & 10YR 5/4 mot; loess
147-166	U&U	5Y 4/1 lt sil; loess
166-169	IIAlb	5Y 4/1 sicl; charcoal flecks N 2/0; mass; BWP
169-172	IIClb	2.5Y 5/4 sicl; mass; BWP

Depth (inches)	Horizon or zone	Description
172-176	IIIA21b	5Y 5/2 sicl; abund med 7.5YR 5/8 & 5Y 7/2 mot; wk fi pl to mass; YSP
176-181	IIIA22b	5Y 5/2 sicl; abund med 5YR 4/8; wk fi pl; YSP
181-184	IIIB21b	5Y 5/1 hvy sicl; com med 5YR 4/6 & 10YR 5/6 mot; wk fi sbk; YSP
184-196	IIIB22b	5Y 5/1 lt sic; abund med 5YR 4/4 & 4/6 mot; mod med sbk; YSP
196-214	IIIB23b	5Y 5/1 lt sic; abund med 5YR 4/4 mot; disc 5Y 4/1 arg; mod med sbk; YSP
214-225	IIIB24b	5GY 5/1 lt sic; few fi 5YR 4/4 & 5Y 6/2 mot; cont 5Y 4/1 arg; mod med sbk; YSP

Site: 16-M30
Drainage: moderately well
Slope: 4%
Elevation: 806.6
Location: 363 ft. S., 118 ft. W. of NE cor. NW¼NW¼ sec. 13, T.80N., R.1W.

0-7	Ap	10YR 2/2 hvy sil; wk fi gr; fri; pH 7.0; a bdy
7-11	A12	10YR 3/2 lt sicl; wk fi sbk; fri; pH 6.9; c bdy
11-19	A13	10YR 3/3 sicl; wk fi sbk; fri; pH 6.1; c bdy
19-26	B21	10YR 4/3 sicl; com fi 10YR 5/6 & 7.5YR 4/4 mot; mod fi sbk; fri; pH 6.0
26-31	B22	10YR 5/4 sicl; m fi 7.5YR 4/4, 10YR 5/6, & 2.5Y 5/4 mot; wk fi sbk; fri; pH 6.1; c bdy
31-34	B23	10YR 5/4 to 2.5Y 5/4 sicl; m med 10YR 5/6 & 2.5Y 5/2 mot; wk fi sbk; fri; com Mn conc 2.5YR 2/2; pH 6.4; g bdy

Depth (inches)	Horizon or zone	Description
34-52	B3	2.5Y 5/4 lt sicl; m med mot as above; wk fi sbk to mass; Mn conc as above; pH 6.6; g bdy
52-87	MOL	2.5Y 5/4 to 5Y 5/3 sil; bands of 7.5YR 5/8 & 5Y 5/2; co Mn conc 2.5YR 2/2; loess
87-174	MOU	10YR 5/6 sil; com med 5Y 5/2 mot; com Mn conc 2.5YR 2/2; loess
174-180	D&U	5Y 5/2 sil; loess
180-205	O&U	Loess
205-246	O&U	Sands
246-293	MOL	Till

Site: 16-M31
Drainage: somewhat poorly
Slope: 3%
Elevation: 803.2
Location: 438 ft. S., 188 ft. W. of NE cor. $NW\frac{1}{4}NW\frac{1}{4}$ sec. 13, T.80N., R.1W.

0-47	Solum	
47-124	MOL	Loess
124-132	O&U	Loess
132-201	D&U	Loess
201-210	O&L	Till

Site: 16-M32
Drainage: somewhat poorly
Slope: 1%
Elevation: 800.6
Location: 415 ft. N., 615 ft. E. of SW cor. $NW\frac{1}{4}NW\frac{1}{4}$ sec. 13, T.80N., R.1W.

0-47	Solum	

Depth (inches)	Horizon or zone	Description
47-103	MOL	Loess
103-167	O&U	Loess
167-214	O&U	Sands
214-226	O&L	Till

Site: 16-M33
Drainage: somewhat poorly
Slope: 1%
Elevation: 772.0
Location: 220 ft. S., 50 ft. W. of SE cor. NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 36, T.80N., R.2W.

0-46	Solum	
46-98	MOL	Loess
98-144	O&U	Loess
144-170	O&U	Till

Site: 16-M34
Drainage: well
Slope: 2-3%
Elevation: 766.0
Location: 180 ft. N., 36 ft. W. of SE cor. NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 36, T.80N., R.2W.

0-7	Ap	10YR 2/1 hvy sil; wk fi gr; fri; pH 7.1; c bdy
7-15	A12	10YR 3/2 sicl; wk fi sbk; fri; pH 6.9; c bdy
15-19	A13	10YR 3/3 sicl; mod fi sbk; fri; pH 6.7; c bdy
19-22	B21	10YR 4/3 sicl; mod med sbk; fri; pH 6.4; c bdy
22-26	B22	10YR 5/4 sicl; mod med sbk; fri; pH 6.3; c bdy

Depth (inches)	Horizon or zone	Description
26-31	B23	10YR 5/4 sicl; mod med sbk; fri; few disc gry ped ct; pH 5.9; c bdy
31-36	B31	10YR 5/4 sicl; wk co pr brk wk med sbk; fri; few disc gry ped ct 10YR 7/2; com Mn conc 2.5YR 2/2; pH 5.9; g bdy
36-41	B32	10YR 5/4 hvy sil; com med 5Y 5/2, 10YR 5/2, & 7.5YR 4/4 mot; wk med sbk; fri; com Mn conc 2.5YR 2/2; pH 6.1; g bdy
41-92	MOL	10YR 5/4 hvy sil to sil w depth; mot as above; loess
92-108	MOU	10YR 5/4 to 5/6 lt sil; mot as above; loess
108-132	MOU	10YR 5/6 cl; com med 10YR 5/4 & 5Y 5/2 mot; till

Site: 16-M35
Drainage: well
Slope: 2-3%
Elevation: 760.0
Location: 300 ft. N., 565 ft. E. of SW cor. NW¼NE¼ sec. 36, T.80N., R.2W.

0-47	Solum	
47-100	MOL	Loess
100-116	O&U	Loess
116-117	O&U	Sand
117-120	O&U	Till

Site: 16-M36
Drainage: well
Slope: 2-3%
Elevation: 756.0
Location: 350 ft. N., 35 ft. E. of SW cor. NW¼NE¼ sec. 36, T.80N., R.2W.

Depth (inches)	Horizon or zone	Description
0-45	Solum	
45-95	MOL	Loess
95-111	O&U	Loess
111-120	O&U	Till

Site: 16-M37
Drainage: well
Slope: 3-4%
Elevation: 749.0
Location: 450 ft. N., 35 ft. E. of SW cor. NW¼NE¼ sec. 36, T.80N., R.2W.

0-40	Solum	
40-85	MOL	Loess
85-116	O&U	Loess
116-138	D&U	Loess
138-146	O&U	Till

Site: 16-M38
Drainage: well
Slope: 3-4%
Elevation: 742.0

Location: 550 ft. N., 35 ft. E. of SW cor. NW¼NE¼ sec. 36, T.80N., R.1W.

0-37	Solum	
37-90	MOL	Loess
90-110	O&U	Loess
110-149	D&U	Loess
149-155	O&U	Till

Site: 16-M39
Drainage: well
Slope: 4%
Elevation: 738.0
Location: 750 ft. N., 35 Ft. E. of SW cor. NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 36, T.80N., R.2W.

Depth (inches)	Horizon or zone	Description
0-31	Solum	
31-96	MOL	Loess
96-102	O&U	Loess
102-122	D&U	Loess
122-126	O&U	Pedisediment
126-133	O&U	Till

Site: 16-M40
Drainage: well
Slope: 4%
Elevation: 732.0
Location: 660 ft. S., 40 ft. E. of NW cor. NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 36, T.80N., R.2W.

0-41	Solum	
41-75	MOL	Loess
75-116	O&U	Loess
116-131	O&U	Loess w inter sand lens
131-166	D&U	Pedisediment
166-172	O&L	Till

Site: 16-M41
Drainage: well
Slope: 1%
Elevation: 888.0
Location: 5 ft. N., 250 ft. E. of SW cor. NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 9, T.82N., R.4W.

Depth (inches)	Horizon or zone	Description
0-8	Ap	10YR 2/2 hvy sil; wk fi gr; fri; pH 7.0; a bdy
8-13	A12	10YR 2/2 lt sicl; wk fi gr; fri; pH 6.4; c bdy
13-17	A13	10YR 3/2 w ext ct 10YR 2/2 lt sicl; wk v fi sbk; fri; pH 6.0; c bdy
17-22	A14	10YR 3/3 w ext ct 10YR 3/2 lt sicl; wk fi sbk; fri; pH 5.9; c bdy
22-27	B21	10YR 4/3 w ext ct 10YR 3/3 lt sicl; wk med sbk; fri; pH 5.8; c bdy
27-36	B22	10YR 4/4 lt sicl; wk med pr brk mod med sbk; fri; m disc gry ped ct; pH 5.6: c bdy
36-42	B3	10YR 5/4 hvy sil; wk med pr brk wk med sbk; fri; com disc gry ped ct; pH 5.6; g bdy
42-51	O&L	10YR 5/4 hvy sil; loess
51-75	O&L	7.5YR 5/6 to 10YR 5/6 sl; sands
75-87	O&L	10YR 5/4 l; till
87-92	O&L	10YR 6/2 & 5/4; shattered limestone mix till

Site: 82-M1
Drainage: well
Slope: 3%
Elevation: 795.0
Location: 610 ft. N., 815 ft. W. of SE cor. NW¼ sec. 30, T. 79N., R.1E.

0-3	Ap1	10YR 3/2 hvy sil; wk fi gr; fri; pH 5.7; c bdy
3-7	Ap2	10YR 2/2 hvy sil; wk fi gr; fri; pH 5.7; c bdy

Depth (inches)	Horizon or zone	Description
7-12	A12	10YR 3/2 w mix 10YR 3/4 lt sicl; wk fi sbk; fri; pH 5.5; c bdy
12-16	B1	10YR 3/3 knd w mix 10YR 3/2, 3/4, & 4/3 sicl; mod fi sbk; fri; few disc gry ped ct; pH 5.4; g bdy
16-19	B21	10YR 3/3 to 4/4 sicl; mod med sbk; fri; few disc gry ped ct; pH 5.4; c bdy
19-28	B22	10YR 4/3 to 4/4 sicl; mod med sbk; fri; cont gry ped ct; few Mn conc 2.5YR 2/2; pH 5.4; g bdy
28-42	B31	10YR 4/3 lt sicl; com med 10YR 5/6 mot; mod med pr brk mod med sbk; fri; disc gry ped ct; m Mn conc 2.5YR 2/2; pH 5.7; g bdy
42-48	B32	10YR 5/4 lt sicl; m med 10YR 5/6 & 5Y 5/3 mot; wk med pr brk wk med sbk; fri; m Mn conc 2.5YR 2/2; pH 5.7; g bdy
48-78	MOL	10YR 5/4 knd sil; mot as above; loess
78-116	MOU	2.5Y 5/4 lt sil; com med 5Y 5/3 & 10YR 5/6 mot; loess
116-120	O&U	10YR 5/6 sil; few fi 5Y 5/3 & 10YR 5/4 mot; pedisediment
120-136	O&L	10YR 5/6 l; till
136-214	O&U	10YR 5/6 l; till

Site: 82-M2
Drainage: Somewhat poorly
Slope: <1%
Elevation: 795.0
Location: 77 ft. S., 433 ft. W. of SE cor. NW$\frac{1}{4}$ sec. 27, T.80N., R.1E.

Depth (inches)	Horizon or zone	Description
0-43	Solum	
43-75	MOL	Loess
75-144	O&U	Loess
144-153	O&L	Till
153-270	O&U	Till

APPENDIX B: LABORATORY DATA

This appendix consists of physical and chemical laboratory data determined on sample horizons for selected soil profiles and weathering zones. Profiles are listed in chronological order. Profiles 16-M1, M3, M4, M5, M15, M26, M28, and M29 also contain a listing of individual sand and silt particle-size fractions in terms of a modified Wentworth size classification.

Abbreviations used in data headings:

AP1	available phosphorus, Bray 1
AP2	available phosphorus, Bray 2
CEC	cation exchange capacity
CO3 EQ	calcium carbonate equivalent
EA	exchangeable acidity
GM	geometric mean
MEQ	milliequivalents per 100 g
MM	millimeter
PPM	parts per million

PROFILE NUMBER: 16-M 1

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		2.2	72.8	25.0	6.1	68.0		3.44		9.6	23.6	0.94
7- 12		2.1	73.0	24.9	5.2	19.5		2.26		13.6	19.1	0.77
12- 16		2.7	72.6	24.7	5.2	9.0		1.35		11.2	16.0	0.65
16- 20		2.9	70.7	26.4	5.4	4.7		0.82		8.8	16.8	0.64
20- 26		2.5	68.8	28.7	5.4	2.5		0.44		9.2	19.9	0.69
26- 30		2.4	68.0	29.6	5.4	6.5		0.41		8.0	20.4	0.69
30- 33		2.3	68.3	29.4	5.4	5.7		0.28		7.2	21.4	0.73
33- 38		1.9	64.9	33.2	5.5	11.0		0.17		8.4	22.9	0.69
38- 44		1.5	64.2	34.3	5.4	25.0		0.11		8.4	24.3	0.71
44- 51		0.9	65.2	33.9	5.5	38.5		0.12		8.0	24.2	0.71
51- 57		0.8	65.3	33.9	5.7	42.5		0.14		7.6	25.6	0.76
57- 63		1.1	70.0	28.9	5.7	39.5		0.12		6.8	23.1	0.80
63- 69		1.1	74.3	24.6	5.7	34.0		0.11		6.0	20.3	0.83
69- 74		0.9	75.2	23.9	5.8	32.0		0.08		5.6		
74- 79		0.8	74.6	24.6	5.9	35.5		0.09		5.6		
79- 85		0.8	75.4	23.8	6.0	28.0		0.08		5.6		
85- 93		0.7	76.2	23.1	6.1	28.0		0.14		4.4		
93- 98		0.8	78.0	21.2	6.3	30.0		0.09		4.0		
98-102		1.1	77.2	21.7	6.3	23.2		0.09		4.0		
102-108		0.5	77.8	21.7	6.4	21.0		0.05				
108-117		0.6	80.3	19.1	6.5	19.2		0.09				
117-125		1.7	84.4	13.9	7.1	12.0		0.08	5.00			
125-130		0.5	78.9	20.6	7.1	24.7		0.07	1.08			
130-136		0.7	85.0	14.3	7.3	15.0		0.06	11.00			
136-142		0.8	84.5	14.7	7.3	9.0		0.06	13.33			
142-148		0.7	86.6	12.7	7.4	7.5		0.04	13.33			
148-149		1.3	88.7	10.0	7.4	5.7			15.50			
149-154		0.8	87.1	12.1	7.4	7.5			14.58			
154-158		0.9	86.0	13.1	7.4	8.0			14.42			
158-160		4.5	84.3	11.2	7.6	5.0			11.83			
160-164		6.6	80.7	12.7	7.5	7.0			13.17			

PROFILE NUMBER: 16-M 1 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
164-168		1.4	80.7	18.0	7.3	19.0			5.08			
168-175		36.3	50.5	13.2	7.4	5.0			9.83			
175-178		73.8	17.0	9.2	7.7	3.5			6.58			
178-179	2.6	80.3	13.2	6.5	7.6	2.7			13.17			
179-182		52.1	36.9	11.0	7.7	3.7			9.92			
182-188		65.3	24.4	10.3	7.8	4.2			5.50			
188-191		85.9	7.8	6.3	7.9	2.5			5.08			
191-195		82.1	10.2	7.7	7.8	2.7			5.10			
195-196		42.7	46.3	11.0	7.9	3.5			10.33			
196-198		81.3	12.6	6.1	7.9	2.7			9.83			
198-202		51.4	19.1	29.5	7.8	3.5			10.08			

PROFILE NUMBER: 16-M 1

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 7	0.0	0.0	0.0	0.0	2.2	15.5	24.5	18.4	9.0	5.4	17.5	2.2	72.8	25.0
7- 12	0.0	0.0	0.0	0.0	2.1	15.9	24.7	17.8	9.1	5.5	17.5	2.1	73.0	24.9
12- 16	0.0	0.0	0.0	0.0	2.7	14.6	25.0	17.9	9.4	5.7	17.3	2.7	72.6	24.7
16- 20	0.0	0.0	0.0	0.0	2.9	13.7	25.0	17.5	9.3	5.3	17.4	2.9	70.8	26.4
20- 26	0.0	0.0	0.0	0.0	2.5	13.9	24.0	17.4	7.8	5.7	17.5	2.5	68.8	28.7
26- 30	0.0	0.0	0.0	0.0	2.4	15.5	25.7	15.1	7.5	4.2	19.0	2.4	68.0	29.6
30- 33	0.0	0.0	0.0	0.0	2.3	16.0	25.4	15.3	7.4	4.2	19.0	2.3	68.3	29.4
33- 38	0.0	0.0	0.0	0.0	1.9	14.3	23.6	15.2	7.7	4.1	18.3	1.9	64.9	33.2
38- 44	0.0	0.0	0.0	0.0	1.5	15.4	22.2	14.3	8.1	4.3	18.2	1.5	64.3	34.3
44- 51	0.0	0.0	0.0	0.0	0.9	15.5	21.4	15.2	8.5	4.7	17.5	0.9	65.3	33.9
51- 57	0.0	0.0	0.0	0.0	0.8	14.2	20.9	15.8	9.4	5.0	16.6	0.8	65.3	33.9
57- 63	0.0	0.0	0.0	0.0	1.1	19.8	26.0	13.8	6.6	3.8	20.1	1.1	70.0	28.9
63- 69	0.0	0.0	0.0	0.0	1.1	23.1	28.9	13.4	5.6	3.3	21.7	1.1	74.3	24.6
69- 74	0.0	0.0	0.0	0.0	0.9	21.3	31.3	13.6	5.7	3.3	21.2	0.9	75.2	23.9
74- 79	0.0	0.0	0.0	0.0	0.8	23.4	29.8	12.7	5.6	3.1	21.9	0.8	74.6	24.6
79- 85	0.0	0.0	0.0	0.0	0.8	23.6	30.1	12.7	5.8	3.2	21.8	0.8	75.4	23.8
85- 93	0.0	0.0	0.0	0.0	0.7	22.2	30.9	14.1	5.9	3.1	21.2	0.7	76.2	23.1
93- 98	0.0	0.0	0.0	0.0	0.8	22.7	31.3	14.6	5.9	3.5	21.1	0.8	78.0	21.2
98-102	0.0	0.0	0.0	0.0	1.1	24.0	29.5	13.8	6.4	3.6	21.4	1.1	77.3	21.7
102-108	0.0	0.0	0.0	0.0	0.5	20.7	32.1	14.7	6.5	3.8	20.2	0.5	77.8	21.7
108-117	0.0	0.0	0.0	0.0	0.6	22.8	33.0	14.4	6.0	4.1	20.8	0.6	80.3	19.1
117-125	0.0	0.0	0.0	0.0	1.7	25.2	34.9	14.6	5.6	4.1	21.8	1.7	84.4	13.9
125-130	0.0	0.0	0.0	0.0	0.5	23.2	31.9	13.4	6.3	4.1	20.8	0.5	78.9	20.6
130-136	0.0	0.0	0.0	0.0	0.7	23.9	37.0	14.7	5.7	3.7	21.4	0.7	85.0	14.3
136-142	0.0	0.0	0.0	0.0	0.8	22.9	34.8	17.0	6.0	3.8	20.7	0.8	84.5	14.7
142-148	0.0	0.0	0.0	0.0	0.7	24.4	37.9	15.8	5.4	3.2	21.7	0.7	86.7	12.7
148-149	0.0	0.0	0.0	0.0	1.3	23.4	40.2	16.2	6.0	2.9	21.7	1.3	88.7	10.0
149-154	0.0	0.0	0.0	0.0	0.8	24.7	37.9	15.9	5.5	3.2	21.7	0.8	87.2	12.1
154-158	0.0	0.0	0.0	0.0	0.9	26.5	37.0	14.0	5.0	3.5	22.4	0.9	86.0	13.1
158-160	0.0	0.0	0.0	0.0	4.5	31.0	31.3	13.4	5.0	3.6	24.6	4.5	84.3	11.2

PROFILE NUMBER: 16-M 1 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
160-164	0.1	0.4	1.4	1.4	3.3	31.1	31.3	11.0	4.4	2.9	27.9	6.6	80.7	12.7
164-168	0.0	0.0	0.0	0.0	1.4	23.2	32.7	14.6	6.2	4.0	21.1	1.4	80.7	18.0
168-175	0.4	3.6	11.2	13.1	8.0	19.9	17.8	7.7	3.3	1.8	61.6	36.3	50.5	13.2
175-178	0.0	11.8	31.7	21.4	8.8	7.5	5.1	2.3	1.7	0.5	181.2	73.7	17.1	9.2
178-179	23.3	24.9	16.9	10.4	4.8	5.0	4.3	1.7	1.4	0.8	366.4	80.3	13.2	6.5
179-182	0.5	8.9	18.8	15.1	8.9	16.0	12.1	4.9	2.2	1.7	100.8	52.2	36.9	11.0
182-188	0.0	3.9	23.5	24.8	13.1	11.3	7.4	2.8	1.8	1.1	124.1	65.3	24.4	10.3
188-191	0.0	9.4	45.5	23.3	7.7	3.7	1.8	1.0	0.6	0.7	238.7	85.9	7.8	6.3
191-195	0.0	3.3	29.5	36.2	13.1	5.3	2.2	1.0	0.9	0.8	177.2	82.1	10.2	7.7
195-196	0.4	2.6	10.7	16.6	12.4	22.0	12.9	6.5	2.4	2.5	67.7	42.7	46.3	11.0
196-198	1.6	26.8	28.4	16.4	8.1	7.8	1.5	1.5	0.9	0.9	257.0	81.3	12.6	6.1
198-202	0.5	4.6	18.0	18.0	10.3	3.2	6.5	5.5	1.9	2.1	113.3	51.4	19.2	29.5

PROFILE NUMBER: 16-M 3

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 4		0.8	74.2	25.0	6.4	37.0		2.37		5.8	21.5	0.86
4- 9		0.8	73.2	26.0	6.4	20.7		2.23		7.1	22.0	0.85
9- 14		0.6	72.1	27.3	6.1	8.5		1.56		7.6	17.8	0.65
14- 18		1.4	71.3	27.3	5.7	6.0		1.12		8.4	18.0	0.66
18- 22		0.9	68.6	30.5	5.6	3.7		0.71		7.6	19.6	0.64
22- 27		1.1	69.3	29.6	5.5	9.5		0.35		7.6	19.8	0.67
27- 32		1.3	70.5	28.2	5.6	17.7		0.31		7.2	21.7	0.77
32- 36		1.8	68.5	29.7	5.6	23.5		0.18		7.2	20.0	0.67
36- 41		1.4	66.5	32.1	5.7	21.0		0.18		6.0	20.6	0.64
41- 47		0.9	68.8	30.3	5.8	16.0		0.16		6.0	22.5	0.74
47- 54		0.6	72.2	27.2	5.8	21.0		0.12		5.2	18.3	0.67
54- 61		0.6	73.1	26.3	5.9	21.0		0.15		3.6	19.8	0.75
61- 67		0.7	75.9	23.4	5.9	18.5		0.14		1.2		
67- 73		0.7	77.5	21.8	5.8	19.0		0.08		2.8		
73- 79		0.5	77.2	22.3	5.8	18.5		0.08		2.4		
79- 85		0.4	77.4	22.2	5.9	17.7		0.08		2.0		
85- 91		0.5	76.1	23.4	5.9	16.5		0.05		2.4		
91- 96		0.4	77.7	21.9	5.9	16.0		0.10		2.4		
96-101		0.6	77.4	22.0	5.9	16.2		0.11		2.4		
101-106		0.7	78.6	20.7	5.8	15.2		0.08				
106-111		0.9	78.8	20.3	5.9	15.7		0.08				
111-116		2.2	78.0	19.8	5.9	16.7		0.10				
116-121		2.2	78.6	19.2	6.1	20.0		0.09				
121-122		4.0	77.2	18.8	6.5	20.5		0.10	0.66			
122-123		12.2	70.9	16.9	6.8	17.2		0.06	7.08			
126-130		18.4	67.3	14.3	6.9	17.7			12.92			
130-132		51.7	36.3	12.0	6.9	22.7			10.17			
132-138		36.2	51.5	12.3	7.0	16.2			13.17			
138-141		54.0	35.8	10.2	7.1	19.0			11.58			
141-146		24.9	61.6	13.5	7.1	15.2			13.58			
146-152		86.3	6.7	7.0	7.2	9.5			4.33			

PROFILE NUMBER: 16-M 3 (CONTINUED)

	% PARTICLE-SIZE											
DEPTH (INCH.)	>2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
152-158		80.6	10.9	8.5	7.3	15.2			5.33			
158-164		71.2	19.7	9.1	7.3	10.5			7.58			
164-170		82.3	10.8	6.9	7.3	7.7			5.08			
170-178		89.9	4.5	5.6	7.3	9.7			5.00			
178-186		86.0	7.1	6.9	7.3	7.5			3.17			
186-193		35.9	33.4	30.7	6.9	12.7		0.09				
193-200		24.3	38.7	37.0	6.8	11.7		0.08				

PROFILE NUMBER: 16-M 3

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
	% PARTICLE-SIZE IN MICRONS													
0- 4	0.0	0.0	0.0	0.0	0.8	17.6	25.4	16.9	8.5	5.8	17.6	0.8	74.2	25.0
4- 9	0.0	0.0	0.0	0.0	0.8	23.0	15.8	20.2	8.6	5.6	17.9	0.8	73.2	26.0
9- 14	0.0	0.0	0.0	0.0	0.6	24.0	17.2	17.5	8.1	5.3	18.7	0.6	72.1	27.3
14- 18	0.0	0.0	0.0	0.0	1.4	16.0	24.5	17.2	8.2	5.4	17.6	1.4	71.3	27.3
18- 22	0.0	0.0	0.0	0.0	0.9	15.1	22.0	18.1	8.2	5.3	17.0	0.9	68.7	30.5
22- 27	0.0	0.0	0.0	0.0	1.1	15.1	22.4	18.4	8.0	5.4	17.1	1.1	69.3	29.6
27- 32	0.0	0.0	0.0	0.0	1.3	17.1	22.9	17.9	7.9	4.7	18.0	1.3	70.5	28.2
32- 36	0.0	0.0	0.0	0.0	1.8	18.5	21.7	15.7	7.4	5.2	18.7	1.8	68.5	29.7
36- 41	0.0	0.0	0.0	0.0	1.4	19.5	22.3	14.0	6.2	4.5	19.7	1.4	66.5	32.1
41- 47	0.0	0.0	0.0	0.0	0.9	19.6	23.8	13.9	6.6	4.9	19.3	0.9	68.8	30.3
47- 54	0.0	0.0	0.0	0.0	0.6	24.5	24.3	13.7	5.7	4.0	21.2	0.6	72.2	27.2
54- 61	0.0	0.0	0.0	0.0	0.6	30.7	21.0	12.5	5.3	3.6	23.1	0.6	73.1	26.3
61- 67	0.0	0.0	0.0	0.0	0.7	22.8	30.4	13.3	5.4	4.0	21.2	0.7	75.9	23.4
67- 73	0.0	0.0	0.0	0.0	0.7	41.2	16.1	12.1	4.5	3.6	25.8	0.7	77.5	21.8
73- 79	0.0	0.0	0.0	0.0	0.5	25.9	25.4	16.3	5.7	4.0	21.0	0.5	77.3	22.3
79- 85	0.0	0.0	0.0	0.0	0.4	22.6	28.3	16.4	6.0	4.1	20.2	0.4	77.4	22.2
85- 91	0.0	0.0	0.0	0.0	0.5	24.1	26.3	16.8	5.7	3.2	21.0	0.5	76.1	23.4
91- 96	0.0	0.0	0.0	0.0	0.4	22.7	26.3	18.4	6.2	4.1	19.8	0.4	77.7	21.9
96-101	0.0	0.0	0.0	0.0	0.6	26.1	24.8	17.4	6.0	3.1	21.3	0.6	77.4	22.0
101-106	0.0	0.0	0.0	0.0	0.7	27.5	26.0	16.5	6.2	2.5	22.1	0.7	78.7	20.7
106-111	0.0	0.0	0.0	0.0	0.9	25.1	28.7	16.9	5.8	2.4	21.8	0.9	78.9	20.3
111-116	0.0	0.4	0.8	0.5	0.5	23.3	28.9	17.5	5.9	2.4	22.5	2.2	78.0	19.8
116-121	0.0	0.3	0.9	0.5	0.5	24.0	28.5	18.2	5.7	2.2	22.7	2.2	78.6	19.2
121-122	0.0	0.6	1.8	1.0	0.6	27.1	24.9	17.4	5.6	2.2	24.9	4.0	77.2	18.8
122-126	0.2	3.0	5.0	2.8	1.2	26.3	23.0	14.9	4.9	1.8	33.8	12.2	70.9	16.9
126-130	0.2	1.7	4.2	5.9	6.4	27.7	17.9	15.0	4.9	1.8	36.6	18.4	67.3	14.3
130-132	0.5	10.9	23.3	12.9	4.1	20.4	3.9	7.9	2.6	1.5	113.8	51.7	36.3	12.0
132-138	1.1	8.0	14.8	8.7	3.6	16.3	18.2	11.6	3.7	1.7	66.4	36.2	51.5	12.3
138-141	0.5	11.9	23.8	13.5	4.3	15.7	8.8	7.4	2.8	1.1	115.3	54.0	35.8	10.2
141-146	0.6	3.6	8.6	7.2	4.9	24.8	21.3	9.8	3.5	2.2	47.9	24.9	61.6	13.5

PROFILE NUMBER: 16-M 3 (CONTINUED)

	% PARTICLE-SIZE IN MICRONS													
DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
146-152	5.2	25.9	34.5	16.4	4.3	2.2	1.8	1.6	0.9	0.2	329.8	86.3	6.7	7.0
152-150	0.8	12.1	37.9	23.4	6.4	5.8	1.4	2.0	1.1	0.6	227.0	80.6	10.9	8.5
150-164	0.7	7.1	39.1	19.2	5.0	9.6	4.0	3.8	1.9	0.5	175.9	71.1	19.8	9.1
164-170	0.8	11.5	36.2	25.6	8.2	6.0	2.1	1.7	0.8	0.2	222.7	82.3	10.8	6.9
170-178	1.7	18.0	44.1	20.7	5.4	2.1	0.7	1.1	0.2	0.4	303.8	89.9	4.5	5.6
178-186	0.9	11.2	39.6	25.8	8.6	3.4	1.3	1.4	0.5	0.5	242.0	86.1	7.1	6.9
186-193	1.1	5.4	13.3	10.4	5.8	8.4	10.6	7.4	3.8	3.2	73.0	36.0	33.4	30.7
193-200	0.7	2.7	8.2	7.6	5.1	7.7	12.5	9.3	5.4	3.8	45.5	24.3	38.7	37.0

PROFILE NUMBER: 16-M 4

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		0.6	72.0	27.4	6.4	99.0		4.12		10.4		
7- 13		0.6	75.2	24.2	5.7	85.0		2.75		12.0		
13- 17		1.6	82.8	15.6	5.3	27.2		0.81		6.8		
17- 23		1.5	74.1	24.4	5.3	24.0		0.44		6.4		
23- 30		2.1	63.7	34.2	5.0	58.0		0.25		7.2		
30- 34		2.1	62.8	35.1	5.1	66.0		0.21		6.8		
34- 38		2.5	63.7	33.8	5.1	58.0		0.21		7.2		
38- 45		1.6	65.7	32.7	5.2	61.5		0.15		4.8		
45- 51		1.8	70.1	28.1	5.3	41.5		0.07		4.4		
51- 56		1.4	72.4	26.2	5.3	35.0		0.09		5.6		
56- 61		1.7	74.1	24.2	5.4	40.0		0.10		4.8		
61- 66		2.6	72.3	25.1	5.5	27.7		0.11		5.2		
66- 71		1.2	74.4	24.4	5.5	26.0		0.09		5.2		
71- 77		1.1	74.3	24.6	5.3	24.5		0.15		5.6		
77- 83		1.2	74.5	24.3	5.5	23.0		0.12		4.8		
83- 89		1.0	74.8	24.2	5.5	21.7		0.07		5.2		
89- 95		1.4	77.5	21.1	5.5	19.0		0.08		5.2		
95-101		2.9	74.9	22.2	5.5	32.5		0.14		5.6		
101-106		2.1	74.8	23.1	5.5	24.5		0.04				
106-112		1.4	76.6	22.0	5.5	26.0		0.08				
112-118		0.7	78.6	20.7	5.5	27.0		0.07				
118-123		0.4	80.0	19.6	5.6	24.5		0.14				
123-128		0.3	80.6	19.1	5.4	26.0		0.15				
128-135		0.5	80.6	18.9	5.6	26.0		0.06				
135-140		0.3	81.8	17.9	5.5	33.0		0.09				
140-145		0.6	80.8	18.6	5.5	28.0		0.12				
145-150		29.9	35.1	35.0	5.5	21.7		0.04				
150-155		31.7	36.8	31.5	5.6	21.0		0.13				
155-165		30.8	38.8	30.4	5.7	19.0		0.10				

PROFILE NUMBER: 16-M 4

DEPTH (INCHES)	% PARTICLE-SIZE IN MICRONS 2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 7	0.0	0.0	0.0	0.0	0.6	13.2	20.5	17.0	12.1	9.2	14.1	0.6	72.0	27.4
7- 13	0.0	0.0	0.0	0.0	0.6	15.9	22.5	17.6	11.2	8.0	15.4	0.6	75.2	24.2
13- 17	0.0	0.0	0.0	0.0	1.6	24.4	21.7	18.8	10.8	7.2	17.8	1.6	82.9	15.6
17- 23	0.0	0.0	0.0	0.0	1.5	15.1	26.3	17.6	8.7	6.4	17.0	1.5	74.1	24.4
23- 30	0.0	0.0	0.0	0.0	2.1	16.4	22.5	13.9	6.3	4.6	19.2	2.1	63.7	34.2
30- 34	0.0	0.0	0.0	0.0	2.1	17.4	23.0	12.4	5.9	4.1	20.1	2.1	62.8	35.1
34- 38	0.0	0.0	0.0	0.0	2.5	18.0	23.8	11.3	4.8	5.8	20.1	2.5	63.7	33.8
38- 45	0.0	0.0	0.0	0.0	1.6	17.9	25.3	13.1	5.6	3.8	20.3	1.6	65.7	32.7
45- 51	0.0	0.0	0.0	0.0	1.8	26.5	24.9	10.8	4.8	3.2	23.6	1.8	70.2	28.1
51- 56	0.0	0.0	0.0	0.0	1.4	25.3	27.4	11.5	5.0	3.2	22.9	1.4	72.4	26.2
56- 61	0.0	0.0	0.0	0.0	1.7	29.9	26.6	10.5	4.2	2.9	24.8	1.7	74.1	24.2
61- 66	0.0	0.0	0.0	0.0	2.6	24.4	26.4	12.6	5.6	3.4	22.6	2.6	72.4	25.1
66- 71	0.0	0.0	0.0	0.0	1.2	21.4	29.1	14.3	5.9	3.8	20.8	1.2	74.5	24.4
71- 77	0.0	0.0	0.0	0.0	1.1	23.2	28.8	13.1	5.6	3.6	21.6	1.1	74.3	24.6
77- 83	0.0	0.0	0.0	0.0	1.2	21.8	29.1	13.8	5.8	4.0	20.9	1.2	74.5	24.3
83- 89	0.0	0.0	0.0	0.0	1.0	19.8	29.5	15.0	6.4	4.1	20.0	1.0	74.8	24.2
89- 95	0.0	0.0	0.0	0.0	1.4	25.6	29.8	13.6	5.2	3.3	22.4	1.4	77.5	21.1
95-101	0.0	0.0	0.0	0.0	2.9	22.0	28.6	14.4	5.8	4.1	21.5	2.9	74.9	22.2
101-106	0.0	0.0	0.0	0.0	2.1	20.0	29.1	15.6	6.0	4.1	20.5	2.1	74.8	23.1
106-112	0.0	0.0	0.0	0.0	1.4	23.5	30.2	13.8	5.9	3.2	21.8	1.4	76.6	22.0
112-118	0.0	0.0	0.0	0.0	0.7	22.8	32.8	14.7	5.4	2.9	21.6	0.7	78.6	20.7
118-123	0.0	0.0	0.0	0.0	0.4	23.0	33.8	14.9	5.6	2.7	21.6	0.4	80.0	19.6
123-128	0.0	0.0	0.0	0.0	0.3	22.9	34.7	14.9	5.4	2.7	21.6	0.3	80.6	19.1
128-135	0.0	0.0	0.0	0.0	0.5	24.5	34.1	13.8	5.6	2.6	22.1	0.5	80.6	18.9
135-140	0.0	0.0	0.0	0.0	0.3	24.5	35.3	14.5	5.0	2.5	22.2	0.3	81.8	17.9
140-145	0.0	0.0	0.0	0.0	0.6	26.6	33.0	13.6	5.1	2.5	22.9	0.6	80.8	18.6
145-150	0.3	3.3	10.4	9.3	6.6	11.0	9.7	7.4	4.3	2.7	60.1	29.9	35.1	35.0
150-155	0.0	2.5	10.8	10.8	7.6	18.0	5.4	7.2	4.0	2.2	64.3	31.7	36.8	31.5
155-165	0.3	2.8	12.0	9.6	6.2	11.7	11.6	8.0	4.8	2.7	58.2	30.9	38.8	30.4

PROFILE NUMBER: 16-M 5

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.7	73.6	24.7	5.6	62.0		2.08		10.9	19.9	0.81
6- 10		1.6	73.2	25.2	5.5	70.0		2.02		10.9	19.5	0.77
10- 16		1.4	71.3	27.3	5.5	7.5		1.00		7.6	17.7	0.65
16- 23		1.2	69.4	29.4	5.6	4.5		0.52		6.7	17.6	0.60
23- 27		1.2	68.9	29.9	5.4	6.2		0.33		6.3	17.8	0.60
27- 32		1.4	69.9	28.7	5.4	7.7		0.29		5.0	18.8	0.66
32- 36		1.6	68.9	29.5	5.3	8.5		0.23		6.4	24.2	0.82
36- 40		2.4	69.4	28.2	5.6	13.0		0.24		6.4	21.6	0.77
40- 49		1.7	71.3	27.0	5.6	20.0				5.2	19.2	0.71
49- 53		1.0	73.7	25.3	5.6	30.0				4.8	21.1	0.83
53- 58		0.8	74.0	25.2	5.6	33.2				4.8	21.6	0.86
58- 63		0.7	74.4	24.9	5.7	33.0						
63- 69		0.8	75.1	24.1	5.7	33.5						
69- 75		0.7	73.0	26.3	5.7	35.5						
75- 81		1.7	72.9	25.4	5.8	30.0						
81- 87		3.5	71.3	25.2	5.8	27.0						
87- 93		0.5	75.2	24.3	5.7	20.7						
93- 99		0.7	79.6	19.7	5.9	16.5						
99-105		0.5	79.0	20.5	5.8	15.0						
105-111		0.6	79.5	19.9	5.6	15.0						
111-117		0.6	79.8	19.6	5.8	19.5						
117-120		0.5	81.3	18.2	6.1	17.5						
120-126		0.7	87.1	12.2	7.1	19.5			8.57			
126-132		0.6	85.9	13.5	7.4	17.5			14.90			
132-140		2.9	84.1	13.0	7.5	16.2			13.88			
140-146		48.4	28.3	23.3	7.4	18.0			0.64			
146-152		52.7	25.3	22.0	7.4	17.5						
152-160		47.3	29.9	22.8	7.3	15.0			1.44			

PROFILE NUMBER: 16-M 5

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 6	0.0	0.0	0.0	0.0	1.7	20.8	24.1	16.0	8.1	4.6	19.3	1.7	73.6	24.7
6- 10	0.0	0.0	0.0	0.0	1.6	20.1	23.6	16.3	8.4	4.8	18.9	1.6	73.2	25.2
10- 16	0.0	0.0	0.0	0.0	1.4	18.8	21.9	17.1	8.5	5.0	18.2	1.4	71.3	27.3
16- 23	0.0	0.0	0.0	0.0	1.2	15.4	24.7	16.5	8.2	4.6	17.8	1.2	69.4	29.4
23- 27	0.0	0.0	0.0	0.0	1.2	15.1	26.9	15.6	7.5	3.8	18.6	1.2	68.9	29.9
27- 32	0.0	0.0	0.0	0.0	1.4	17.2	25.2	17.4	5.3	4.8	19.0	1.4	69.9	28.7
32- 36	0.0	0.0	0.0	0.0	1.6	18.2	24.9	14.5	6.7	4.6	19.3	1.6	68.9	29.5
36- 40	0.0	0.0	0.0	0.0	2.4	18.7	26.0	13.4	6.8	4.5	20.0	2.4	69.4	28.2
40- 49	0.0	0.0	0.0	0.0	1.7	20.9	27.4	12.8	6.3	3.9	20.9	1.7	71.3	27.0
49- 53	0.0	0.0	0.0	0.0	1.0	22.3	28.4	12.9	6.2	3.9	21.0	1.0	73.7	25.3
53- 58	0.0	0.0	0.0	0.0	0.8	21.1	29.1	13.8	6.1	3.9	20.5	0.8	74.0	25.2
58- 63	0.0	0.0	0.0	0.0	0.7	23.2	28.6	13.0	5.8	3.8	21.2	0.7	74.4	24.9
63- 69	0.0	0.0	0.0	0.0	0.8	22.4	29.0	14.0	6.0	3.8	20.9	0.8	75.2	24.1

PROFILE NUMBER: 16-M 6

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		1.4	71.4	27.2	5.8	98.2		1.84		8.4	22.1	0.81
7- 11		1.5	70.3	28.2	5.8	84.0		1.79		8.4	21.6	0.77
11- 15		1.4	69.5	29.1	5.6	15.5		1.30		9.2	18.5	0.64
15- 21		1.3	69.2	29.5	5.3	9.2		1.02		8.4	18.5	0.63
21- 25		1.2	69.3	29.5	5.6	4.7		0.56		6.4	19.7	0.67
25- 30		1.2	68.6	30.2	5.5	6.7		0.33		6.4	19.4	0.64
30- 35		1.4	68.5	30.1	5.5	9.2		0.18		5.2	19.3	0.64
35- 42		2.2	67.5	30.3	5.5	9.5		0.15		5.2	23.4	0.77
42- 47		1.6	66.9	31.5	5.6	20.5				6.0	23.8	0.76
47- 52		1.3	70.2	28.5	5.7	32.5				5.2	24.7	0.87
52- 58		0.6	72.9	26.5	5.7	37.5				4.4	18.6	0.70
58- 64		0.8	74.5	24.7	5.8	37.0						
64- 70		0.9	73.1	26.0	5.8	33.5						
70- 76		0.7	74.6	24.7	5.9	25.2						
76- 82		0.6	75.4	24.0	5.9	21.2						
82- 88		0.6	77.0	22.4	5.9	16.0						
88- 94		0.7	76.9	22.4	6.0	14.0						
94-100		0.9	79.6	19.5	6.2	14.2						
100-106		0.6	80.0	19.4	6.1	20.0						
106-113		0.8	86.4	12.8	7.2	16.5						
113-119		0.8	87.7	11.5	7.4	14.0						
119-125		0.6	87.4	12.0	7.2	13.0						
125-131		1.3	86.1	12.6	7.4	12.0						
131-136		1.7	85.6	12.7	7.4	10.5						
136-140		5.0	80.7	14.3	7.5	12.5						
140-148		26.3	60.4	13.3	7.5	10.5						
148-155		47.9	38.5	13.6	7.5	8.5						
155-159		68.9	19.7	11.4	7.4	5.5						
159-164		80.0	10.2	9.8	7.5	4.5						

PROFILE NUMBER: 16-M 6

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
166-172		71.8	17.4	10.8	7.5	4.0						
172-179		64.4	24.1	11.5	7.6	3.5						

PROFILE NUMBER: 16-M 7A

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CC3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 8		0.9	73.7	25.4	7.3	28.4	41.5	2.03		4.4	23.8	0.94
8- 11		0.9	73.1	26.0	7.4	26.0	28.8	1.97		4.4	22.9	0.88
11- 14		0.9	70.5	28.6	6.7	7.4	7.4	1.91		6.4	21.8	0.76
14- 19		0.7	70.0	29.3	6.1	3.9	4.0	1.28		7.6	22.3	0.76
19- 23		0.8	69.4	29.8	5.8	3.7	4.8	0.75		6.8	22.0	0.74
23- 29		0.7	69.7	29.6	5.8	4.2	4.8	0.69		6.4	22.5	0.76
29- 35		0.6	70.0	29.4	5.7	14.0		0.32		6.4	22.7	0.77
35- 41		0.8	70.0	29.2	5.7	17.0		0.17		6.4	22.9	0.78
41- 44		0.5	70.2	29.3	5.9	19.2		0.09		5.2	21.2	0.72
44- 50		0.9	70.5	28.6	6.1	18.7		0.06		3.6	20.6	0.72
50- 56		0.8	74.2	25.0	6.3	16.2		0.06		4.0	19.7	0.79
56- 62		0.6	74.1	25.3	6.2	16.4		0.07		4.0	20.3	0.80
62- 70		0.6	77.3	22.1	6.3	17.8						
70- 76		0.6	77.2	22.2	6.6	19.4						
76- 82		0.7	78.3	21.0	6.9	15.5						
82- 88		0.5	78.5	21.0	7.2	9.7						
88- 94		1.0	83.3	15.7	7.7	4.8						
94- 99		0.8	84.5	14.7	7.9	3.9						
99-103		0.9	86.5	12.6	7.9	3.9						
103-109		0.6	85.9	13.5	8.1	3.9						
109-115		0.6	86.9	12.5	8.2	3.4						
115-121		0.7	85.8	13.5	8.2	3.9						
121-127		0.6	87.1	12.3	8.3	3.3						
127-132		0.8	86.9	12.3	8.3	3.4						
132-137		0.6	86.3	13.1	8.3	3.3						
137-142		1.3	86.2	12.5	8.1	3.1						
142-150		2.6	83.1	14.3	8.2	2.8						
150-154		20.5	60.1	19.4	8.1	4.5						
154-160		59.3	26.5	14.2	8.1	3.1						
160-168		73.1	15.7	11.2	8.3	4.1						
168-176		74.7	14.9	10.4	8.4	3.0						

PROFILE NUMBER: 16-M 7A (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC < 2
176-186		80.0	10.5	9.5	8.4	4.2						
186-194		85.6	6.4	8.0	8.4	2.7						
210-215		35.2	35.6	29.2	8.0	5.0						

PROFILE NUMBER: 16-M 7B

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.0	72.7	26.3	6.7	36.2	40.0	1.88		4.0	22.2	0.84
6- 12		0.9	71.4	27.7	6.4	17.0	21.7	1.51		6.0	23.3	0.84
12- 18		1.1	70.0	28.9	6.9	5.0	6.6	1.11		6.0	21.9	0.76
18- 24		0.5	67.9	31.6	6.1	3.0	3.7	0.65		8.4	22.6	0.72
24- 30		0.7	68.6	30.7	5.8	7.1	7.9	0.19		7.4	21.7	0.71
30- 36		1.1	69.1	29.8	5.6	13.3	17.8	0.11		7.2	22.5	0.76
36- 42		1.0	69.7	29.3	5.7	17.1	29.5	0.11		6.0	22.7	0.77
42- 48		0.9	70.8	28.3	5.7	17.7	36.8			5.6	22.9	0.81
48- 54		0.7	74.1	25.2	5.7	17.6	63.0	0.01		4.0	19.5	0.77
54- 60		0.6	75.7	23.7	5.8	19.5	85.0			4.0	20.3	0.86

PROFILE NUMBER: 16-M 7C

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	API PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.3	75.1	23.6	6.8	23.0	24.0	1.76		3.6	21.0	0.89
6- 12		1.1	72.8	26.1	6.8	25.2	37.5	1.54		4.8	20.3	0.78
12- 18		1.0	69.8	29.2	5.8	3.8	4.3	0.95		13.2	17.8	0.61
18- 24		0.9	69.5	29.6	5.4	3.3	3.4	0.45		7.2	19.6	0.66
24- 30		0.7	68.1	31.2	5.7	6.1	8.3	0.24		6.8	22.5	0.72
30- 36		1.1	68.3	30.6	5.7	15.4	22.0	0.13		5.6	20.7	0.68
36- 42		1.1	70.9	28.0	5.7	25.3	45.3	0.13		5.6	21.0	0.75
42- 48		0.8	72.2	27.0	5.8	23.0	61.0	0.10		5.2	21.2	0.79
48- 54		0.5	74.4	25.1	6.0	18.4	82.0	0.10		4.0	20.7	0.82
54- 60		0.6	74.5	24.9	6.1	18.0	91.0	0.04		3.6	20.1	0.81

PROFILE NUMBER: 16-M 7D

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.6	72.9	25.5	7.1	28.6	33.0	1.72		4.0	21.3	0.84
6- 12		1.8	71.9	26.3	7.0	16.6	17.5	1.67		4.8	19.8	0.75
12- 18		1.8	69.4	28.8	6.0	4.3	6.0	1.23		8.0	18.9	0.66
18- 24		1.4	69.2	29.4	5.8	5.0	6.4	0.91		8.0	20.1	0.68
24- 30		1.2	70.0	28.8	5.7	6.7	6.7	0.69		6.8	20.2	0.70
30- 36		1.3	70.0	28.7	5.6	11.7	16.5	0.13		6.4	21.6	0.75
36- 42		1.2	71.3	27.5	5.6	26.8	56.0			4.8	20.7	0.75
42- 48		0.9	71.6	27.5	5.7	27.7	67.4			4.8	20.4	0.74
48- 54		0.7	73.8	25.5	5.8	23.6	87.0			3.6	19.3	0.76
54- 60		0.7	75.1	24.2	5.9	26.8	92.0			2.8	18.2	0.75

PROFILE NUMBER: 16-M 7E

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		2.2	72.6	25.2	6.8	31.4	43.0	1.64		4.8	21.2	0.84
6- 12		2.2	70.3	27.5	6.6	20.6	25.8	1.25		4.8	21.0	0.76
12- 18		1.4	66.2	32.4	5.7	5.4	5.8	0.32		6.0	24.2	0.75
18- 24		0.8	65.5	33.7	5.6	6.5	16.8	0.17		6.4	27.7	0.82
24- 30		1.8	66.9	31.3	5.6	12.4	19.3	0.06		6.0	24.6	0.79
30- 36		1.6	68.2	30.2	5.6	22.8	29.8			5.6	24.1	0.80
36- 42		2.0	68.5	29.5	5.8	26.5	39.2	0.03		5.6	24.6	0.83
42- 48		1.5	70.1	28.4	5.8	21.0	40.8	0.06		4.8	23.8	0.84
48- 54		1.0	73.0	26.0	5.9	19.8	68.8	0.03		3.2	21.6	0.83
54- 60		0.7	74.8	24.5	6.2	17.8	86.0	0.05		3.2	21.3	0.87

PROFILE NUMBER: 16-M 7F

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		2.5	73.0	24.5	7.2	36.0	47.0	1.89		3.6	21.7	0.89
6- 12		2.7	71.3	26.0	7.1	24.4	26.4	1.79		4.4	20.4	0.78
12- 18		2.8	70.5	26.7	6.0	5.5	11.5	1.22		5.6	17.2	0.64
18- 24		1.7	67.3	31.0	5.6	8.3	8.5	0.56		6.8	19.9	0.64
24- 30		1.1	67.4	31.5	5.6	14.2	22.8	0.20		5.6	22.4	0.71
30- 36		1.8	68.8	29.4	5.6	24.5	47.0	0.08		6.0	24.9	0.85
36- 42		2.1	68.4	29.5	5.7	28.4	60.0	0.07		6.6	29.5	1.00
42- 48		1.5	69.5	29.0	5.7	21.7	71.2	0.04		4.4	28.6	0.99
48- 54		1.5	71.2	27.3	5.9	16.3	74.0	0.01		4.0	26.5	0.97
54- 60		1.3	74.1	24.6	6.1	15.2	88.4			3.6	24.3	0.99

PROFILE NUMBER: 16-M 7G

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		2.6	72.0	25.4	7.1	55.4	68.8	1.90		4.0	23.0	0.91
6- 12		2.4	70.9	26.7	6.9	29.8	35.6	1.81		5.2	23.2	0.87
12- 18		2.3	69.2	28.5	5.8	6.3	8.0	0.97		8.4	18.2	0.64
18- 24		1.5	67.2	31.3	5.7	6.5	7.5	0.43		7.2	20.1	0.64
24- 30		1.1	66.8	32.1	5.6	14.3	17.2	0.19		6.0	24.0	0.75
30- 36		1.7	68.3	30.0	5.7	17.3	27.5	0.07		5.7	24.4	0.81
36- 42		1.3	69.4	29.3	6.1	24.9	43.4			4.8	26.3	0.90
42- 48		1.0	71.8	27.2	6.2	22.4	66.0	0.06		4.8	24.1	0.89
48- 54		1.3	71.1	27.6	6.3	16.1	84.0	0.01		3.6	24.4	0.88
54- 60		1.3	73.3	25.4	6.5	13.6	83.2			2.4	22.6	0.89

PROFILE NUMBER: 16-M 7H

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.5	70.6	27.9	7.1	53.2	78.5	2.11		3.2	27.0	0.97
6- 12		1.7	69.5	28.8	7.1	20.0	23.6	1.53		4.4	29.3	1.02
12- 18		1.4	67.6	31.0	6.7	14.4	15.0	0.95		4.8	27.4	0.88
18- 24		0.8	64.1	35.1	6.5	7.0	7.8	0.37		5.3	29.6	0.84
24- 30		1.4	64.1	34.5	6.3	12.8	17.0	0.09		4.8	31.1	0.90
30- 36		1.4	65.5	33.1	6.5	16.1	27.0	0.04		4.8	30.6	0.92
36- 42		1.1	69.3	29.6	6.8	22.4	54.0			7.5	28.0	0.95
42- 48		1.7	69.6	28.7	6.8	29.9	77.0			7.5	27.9	0.97
48- 54		0.7	69.4	29.9	6.8	30.8	82.0			7.5	27.5	0.92
54- 60		0.4	72.5	27.1	6.8	30.8	111.2			7.9	26.3	0.97

PROFILE NUMBER: 16-M 7I

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		2.6	65.1	32.3	7.1	44.0	79.6	2.46		4.2	31.2	0.97
6- 12		0.7	64.5	34.8	7.1	24.5	30.0	2.02		4.4	32.6	0.94
12- 18		1.0	59.7	39.3	7.1	7.3	8.7	0.93		4.4	32.4	0.82
18- 24		1.1	61.9	37.0	7.0	5.5	21.3	0.50		4.0	27.5	0.74
24- 30		1.0	67.1	31.9	7.0	4.0	59.0	0.29		2.2	26.3	0.82
30- 36		1.5	71.2	27.3	7.1	3.6	50.4	0.17		1.8	24.2	0.89
36- 42		1.6	73.6	24.8	7.2	4.5	118.8	0.09		1.3	21.8	0.88
42- 48		1.3	73.2	25.5	7.3	4.8	113.2	0.05		0.8	22.1	0.87
48- 54		1.5	72.9	25.6	7.4	5.1	113.2	0.06		1.3	24.3	0.95

PROFILE NUMBER: 16-M 7J

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		0.5	71.2	28.3	6.7	62.0	91.2	2.41		4.6	29.0	1.02
6- 12		0.6	69.6	29.8	6.8	44.0	51.0	2.45		5.0	31.9	1.07
12- 18		1.1	67.1	31.8	6.9	9.0	10.8	1.89		5.5	31.5	0.99
18- 24		1.3	65.2	33.5	6.9	5.8	11.8	0.95		5.0	32.3	0.96
24- 30		0.8	63.8	35.4	7.0	4.3	30.8	0.33		3.4	30.2	0.85
30- 36		1.5	69.8	28.7	7.2	2.7	71.0	0.21		2.1	30.4	1.06
36- 42		1.2	73.0	25.8	7.4	2.6	102.8	0.12	1.76	1.7	30.8	1.19
42- 48		1.1	72.7	26.2	7.4	3.7	106.0	0.07	3.62	1.3	27.8	1.06
48- 54		1.1	72.9	26.0	7.4	4.3	140.0	0.05	4.21	0.8	27.5	1.06
54- 60		0.9	72.8	26.3	7.4	4.6	133.2	0.06	4.12	2.1	27.4	1.04

PROFILE NUMBER: 16-M 7K

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		0.9	75.0	24.1	7.1	43.0	92.8	1.83		2.5	24.6	1.02
6- 12		0.7	74.3	25.0	6.7	35.4	46.0	2.41		5.0	27.2	1.09
12- 18		0.9	66.2	32.9	6.1	4.5	19.2	1.87		8.0	33.0	1.00
18- 24		0.8	60.1	39.1	6.3	5.7	12.8	0.96		5.9	35.4	0.91
24- 30		0.9	59.4	39.7	6.5	2.7	16.8	0.47		4.8	36.6	0.92
30- 36		0.9	65.5	33.6	7.0	2.5	40.0	0.21		2.8	33.5	1.00
36- 42		1.6	71.1	27.3	7.3	2.0	55.2	0.13		1.6	30.4	1.11
42- 48		1.5	72.7	25.8	7.3	2.2	86.0	0.06		1.6	28.7	1.11
48- 54		1.2	73.4	25.4	7.3	3.0	110.0	0.06		1.2	28.3	1.11

PROFILE NUMBER: 16-M 8

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 5		1.3	72.1	26.6	5.9	14.5		2.30		8.0	21.2	0.80
5- 8		1.2	72.2	26.6	5.9	11.0		2.04		8.0	21.4	0.80
8- 14		1.0	70.4	28.6	5.3	6.0		1.45		9.6	18.4	0.64
14- 20		0.9	69.6	29.5	5.2	5.0		1.05		9.2	17.5	0.59
20- 26		0.9	70.1	29.0	5.2	3.5		0.81		7.6	17.5	0.60
26- 33		0.9	70.1	29.0	5.3	11.7		0.36		6.4	18.2	0.63
33- 38		1.2	67.9	30.9	5.4	18.0		0.16		6.0	23.0	0.74
38- 45		1.4	66.9	31.7	5.5	19.5		0.18		5.6	23.7	0.75
45- 50		1.0	66.2	32.8	5.6	22.0				4.8	26.3	0.80
50- 55		0.8	68.6	30.6	5.6	25.5				4.4	22.3	0.73
55- 61		0.7	71.3	28.0	5.6	26.5				4.0	21.0	0.75
61- 68		0.7	75.4	23.9	5.6	27.0				2.8		
68- 74		0.7	76.6	22.7	5.7	28.0						
74- 80		0.6	77.3	22.1	5.8	23.0						
80- 86		0.5	77.6	21.9	5.8	19.0						
86- 92		0.6	77.8	21.6	5.8	19.5						
92- 98		0.6	78.7	20.7	5.9	20.5						
98-104		0.5	79.0	20.5	6.0	23.5						
104-110		0.6	80.8	18.6	6.1	23.5						
110-116		0.6	83.5	15.9	6.5	21.0						
116-123		1.1	86.9	12.0	7.1	17.5						
123-130		0.7	88.6	10.7	7.2	19.0						
130-137		0.3	86.8	12.9	7.4	9.5						
137-140		0.4	87.6	12.0	7.5	6.5						
140-146		0.5	87.7	11.8	7.5	4.7						
146-148		0.5	88.6	10.9	7.6	4.5						
148-154		2.7	85.0	12.3	7.6	4.0						
154-156		4.3	84.6	11.1	7.5	3.5						
156-158		15.5	71.7	12.8	7.5	5.2						
158-162		17.3	67.6	15.1	7.5	5.0						
162-167		23.9	61.3	14.8	7.5	3.2						

PROFILE NUMBER: 16-M 8 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
167-172		48.3	35.7	16.0	7.5	3.0						
172-173		18.9	63.7	17.4	7.5	3.0						
173-174		65.6	18.1	16.3	7.6	2.5						
174-177		65.3	23.7	11.0	7.7	2.5						
177-182		46.5	40.6	12.9	7.8	4.0						
182-186		60.6	25.3	14.1	7.7	3.0						
186-190	0.4	67.0	17.1	15.9	7.7	3.5						
190-192		43.5	38.6	17.9	7.7	2.5						
192-196	0.3	69.2	18.2	12.6	7.7	3.0						
196-201		66.0	18.7	15.3	7.8	3.0						
201-205	0.3	74.9	13.9	11.2	7.9	3.7						
205-211	1.4	87.9	5.4	6.7	7.9	3.5						
211-215		80.7	10.2	9.1	7.9	4.7			4.17			
215-221	0.6	87.6	5.1	7.3	7.9	7.5			5.08			
221-225	0.4	75.5	11.8	12.7	7.9	7.2			0.70			
225-232	0.8	33.2	32.6	34.2	7.4	10.0			0.01			
232-240	0.7	32.5	31.9	35.7	7.3	9.2			0.07			

PROFILE NUMBER: 16-M 9

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 5		5.4	72.0	22.6	6.1			2.39		9.6		
5- 11		4.9	72.0	23.1	5.5			2.23		12.4		
11- 15		3.1	71.1	25.8	5.1			1.00		9.6		
15- 22		1.9	68.1	30.0	5.0	26.5		0.45		8.4		
22- 25		1.6	65.9	32.5	5.1	14.2		0.34		7.6		
25- 31		1.3	67.0	31.7	5.1	11.0		0.23		6.4		
31- 36		0.9	63.0	36.1	5.4	21.0		0.21		6.0		
36- 41		0.6	65.3	34.1	5.5	33.5		0.17		5.6		
41- 45		0.4	66.5	33.1	5.6	40.0		0.13		5.2		
45- 50		0.6	68.8	30.6	5.7	41.0		0.13		5.2		
50- 55		0.5	68.8	30.7	5.7	35.0		0.15		4.4		
55- 61		0.4	72.0	27.6	5.8	24.5		0.11		4.4		
61- 67		0.5	73.8	25.7	5.8	20.5		0.08		3.6		
67- 73		0.6	74.8	24.6	5.8	18.7		0.23		3.2		
73- 76		0.7	74.9	24.4	5.9	17.0		0.06				
76- 78		0.8	75.1	24.1	6.0	19.5		0.07				
78- 84		0.7	76.1	23.2	6.2	19.0						
84- 90		0.9	76.5	22.6	6.3	20.5		0.01				
90- 96		0.7	77.9	21.4	6.3	23.0		0.04				
96-102		0.6	79.2	20.2	6.3	23.0		0.08				
102-108		0.9	86.6	12.5	7.2	14.0		0.05	5.67			
108-114		0.9	86.7	12.4	7.7	10.0		0.02	12.00			
114-121		3.4	85.3	11.3	7.7	9.0		0.06	12.01			
121-128	0.3	81.6	11.8	6.6	7.5	5.5		0.06	1.98			
128-134	0.2	81.6	12.2	6.2	7.4	5.2		0.05	2.67			
134-140	0.2	80.3	13.0	6.7	7.6	4.5		0.07	5.17			
140-146		80.1	12.8	7.1	7.6	6.5		0.04	3.58			
146-150		85.9	8.6	5.5	7.5	5.2		0.04	1.00			
150-151		89.2	5.0	5.8	7.4	5.2		0.06	3.25			
151-154		84.1	9.4	6.5	7.5	5.5		0.07	2.00			
154-160		85.7	8.1	6.2	7.5	6.0		0.06	1.92			

PROFILE NUMBER: 16-M 9 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
160-165		86.4	7.3	6.3	7.5	7.2		0.03	0.98			
165-169		80.7	12.2	7.1	7.5	11.0		0.02	1.51			
169-176		36.8	50.5	12.7	7.1	17.5		0.02				
169-176		89.0	4.9	6.1	7.3	14.0		0.04	1.03			
176-182		82.4	9.7	7.9	6.9	15.0		0.02				
182-188		36.5	50.0	13.5	7.1	17.5		0.10				
182-188		78.2	13.2	8.6	7.1	14.0		0.10				
188-194		39.0	49.4	11.6	7.8	16.2		0.31	8.20			
194-199		14.5	72.4	13.1	7.8	15.0		0.44	11.36			
199-204		5.2	80.7	14.1	7.9	11.5		0.47	11.32			
204-209		1.9	87.8	10.3	7.9	6.5		0.52	13.30			
209-214		1.0	87.0	12.0	7.9	5.0		0.50	16.02			
214-222		7.7	83.0	9.3	7.9	4.0		0.15	16.47			
222-226		5.2	81.6	13.2	7.9	4.5		0.22	15.45			
226-232	8.3	51.2	30.5	18.3	7.4	3.0		0.06				
232-239	2.7	32.6	39.5	27.9	7.2	5.0						
239-245	8.3	47.2	30.0	22.8	7.2	5.5						
245-251	4.5	47.6	29.9	22.5	7.3	3.2						
251-257	5.5	49.1	28.8	22.1	7.2	3.7						
257-263	10.6	43.8	34.7	21.5	7.2	3.0						
263-269	7.3	49.1	30.0	20.9	7.2	3.2						
269-275	10.8	51.4	28.4	20.2	7.2	6.2						
275-278	5.1	51.3	29.1	19.5	7.2	7.2						

PROFILE NUMBER: 16-M15

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 8		3.6	72.4	24.0	5.9			1.76				
8- 11		3.0	71.1	25.9	5.4	21.0	26.4	0.92				
11- 16		2.8	68.9	28.3	5.3	17.0	22.8	0.81				
16- 20		2.1	65.1	32.8	5.2	30.5	46.8	0.43				
23- 28		1.9	66.2	31.9	5.3	58.0	97.6	0.23				
28- 34		1.3	65.4	33.3	5.3	60.0	110.0	0.14				
34- 39		0.9	67.9	31.2	5.4	54.8	120.0	0.14				
39- 44		1.3	68.8	29.9	5.5	54.8	135.0	0.12				
44- 50		1.5	70.1	28.4	5.5	56.4	135.0					
50- 56		1.5	70.8	27.7	5.6	50.8	132.0					
56- 62		1.2	72.5	26.3	5.8	42.5	125.0					
62- 68		1.1	75.1	23.8	5.8	38.5	125.0					
68- 74		0.7	75.8	23.5	6.0	32.0	125.0					
74- 80		0.7	76.9	22.4	6.2	28.0	135.0					
80- 86		0.6	76.7	22.7	6.3	24.5	150.0					
86- 91		0.7	77.6	21.7	6.5	26.2	165.0					
91- 97		0.5	79.6	19.9	6.8	18.0	160.0	0.07				
97-103		1.0	83.0	16.0	7.6	10.0	130.0	0.18	5.89			
103-110		0.5	85.9	13.6	7.9	7.3	130.0	0.12	12.52			
110-112		1.0	84.4	14.6	7.9	6.0	110.0	0.11	14.34			
112-117		1.0	86.1	12.9	7.8	3.8	90.0	0.11	16.74			
117-121		0.6	85.8	13.6	7.8	5.0	60.0	0.09	16.48			
121-127		0.4	86.4	13.2	8.0	3.8	63.0	0.44	14.68			
127-133		0.9	85.5	13.6	8.0	3.0	29.0	0.59	13.66			
133-139		0.4	86.0	13.6	8.0	2.3	37.5	0.36	14.67			
139-147		0.7	85.3	14.0	8.0	2.3	35.0	0.36	14.40			
147-151		0.7	85.0	14.3	8.0	2.3	32.0	0.50	13.97			
151-155		0.5	85.9	13.6	7.7	3.5	34.5	0.55	13.98			
155-161		0.6	86.4	13.0	7.7	3.7	36.5	0.35	14.19			
161-167		0.8	85.0	14.2	8.0	2.5	32.7	0.65	12.66			
167-172		0.8	85.8	13.4	7.9	1.3	32.7	0.38	15.16			

PROFILE NUMBER: 16-M15 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
172-176		1.0	85.2	13.8	8.0	1.4	20.7	0.37	14.99			
176-180		2.7	86.1	11.2	7.9	1.2	5.6	0.83	12.22			
180-185		1.0	84.9	14.1	7.8	1.5	8.0	0.59	14.62			
185-190		1.1	84.1	14.8	7.8	1.5	5.0	0.98	8.36			
190-194		1.1	84.1	14.8	8.0	1.8	9.4	0.77	10.07			
194-206		1.9	85.2	12.9	8.0	2.0	5.0	0.62	9.17			
206-218		1.2	82.6	16.2	8.0	2.0	8.8	0.91	5.66			
218-230		1.5	82.8	15.7	7.9	2.0	12.0	0.68	7.06			
230-236		0.5	89.0	10.5	7.9	1.5	8.0	0.86	11.55			
236-241		0.7	83.7	15.6	7.8	1.8	16.5	0.60	8.92			
241-247		0.6	83.5	15.9	7.8	1.5	11.7	0.77	7.01			
247-259		1.7	84.1	14.2	7.9	1.0	6.8	0.90	10.66			
259-265		0.8	84.3	14.9	8.0	1.3	7.0	1.00	8.14			
265-271		0.2	85.3	14.5	7.9	1.2	14.5	1.06	9.95			
271-276		0.2	88.9	11.0	7.9	1.4	13.2	1.03	12.63			
276-280		0.2	90.4	9.5	8.0	1.0	7.8	0.97	16.64			
280-285		0.2	89.2	10.6	8.0	1.5	6.0	1.03	16.24			
285-290		0.2	88.2	11.6	7.9	1.5	6.4	1.37	14.32			
290-295		0.4	88.9	10.8	7.9	2.0	7.3	2.42	8.31			
295-299		0.5	91.0	8.5	7.8	2.5	8.0	2.02	12.40			
299-302		0.7	88.7	10.6	7.8	3.0	6.3	2.27	8.96			
302-306		1.1	86.6	12.3	7.5	5.0	39.2	0.37	2.50			
306-309		1.5	82.6	15.9	7.2	5.5	35.5		1.80			
309-313		0.9	78.2	20.9	7.1	6.5	35.5	0.08	1.00			
313-316		0.5	74.5	25.0	7.0	6.8	34.8	0.20				
316-320		0.7	75.4	23.9	7.0	7.0	33.8	0.21	1.60			
320-323		0.5	72.1	27.4	6.9	6.5	30.8		2.00			
323-329		0.8	72.2	27.0	7.0	5.8	24.3		5.50			
329-333		0.8	68.1	31.1	7.1	6.0	24.3		0.60			
333-337		0.5	55.0	44.5	7.1	4.9	15.7		2.10			
337-341		2.3	56.0	41.7	7.5	3.0	8.3					
341-344		1.9	63.0	35.1	7.7	3.5	13.3					

PROFILE NUMBER: 16-M15 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
344-348		1.4	63.9	34.8	7.6	4.5	18.4					
348-352		1.7	64.3	34.0	7.8	4.5	18.4					
352-357		2.2	63.5	34.3	7.9	5.5	21.8					
357-362		3.7	62.3	34.0	7.9	5.5	25.2					
362-367		4.1	58.4	37.5	7.9	7.5	28.5					

PROFILE NUMBER: 16-M15

	% PARTICLE-SIZE IN MICRONS													
DEPTH	2000	1000	500	250	125	62	31	16	8	4		2000	62	
(INCHES)	1000	500	250	125	62	31	16	8	4	2	GM	62	2	< 2
0- 8	0.0	0.0	0.0	0.0	3.6	15.0	25.6	17.6	9.0	5.2	18.2	3.6	72.4	24.0
8- 11	0.0	0.0	0.0	0.0	3.0	14.8	25.3	16.5	9.5	5.0	17.9	3.0	71.1	25.9
11- 16	0.0	0.0	0.0	0.0	2.8	15.4	24.5	15.4	8.4	5.2	18.2	2.8	68.9	28.3
16- 20	0.0	0.0	0.0	0.0	2.1	14.9	24.2	14.5	7.4	4.1	18.7	2.1	65.1	32.8
23- 28	0.0	0.0	0.0	0.0	1.9	15.2	24.6	14.8	7.3	4.3	18.6	1.9	66.2	31.9
28- 34	0.0	0.0	0.0	0.0	1.3	14.0	23.2	15.4	8.0	4.8	17.5	1.3	65.4	33.3
34- 39	0.0	0.0	0.0	0.0	0.9	17.4	27.0	13.2	6.2	4.1	19.6	0.9	67.9	31.2
39- 44	0.0	0.0	0.0	0.0	1.3	16.6	26.6	14.5	7.0	4.1	19.1	1.3	68.8	29.9
44- 50	0.0	0.0	0.0	0.0	1.5	20.9	28.0	12.3	5.3	3.6	21.4	1.5	70.1	28.4
50- 56	0.0	0.0	0.0	0.0	1.5	18.9	29.5	13.4	5.2	3.8	20.8	1.5	70.8	27.7
56- 62	0.0	0.0	0.0	0.0	1.2	19.7	30.0	14.0	5.4	3.4	20.9	1.2	72.5	26.3
62- 68	0.0	0.0	0.0	0.0	1.1	21.9	31.1	13.4	5.5	3.2	21.5	1.1	75.1	23.8
68- 74	0.0	0.0	0.0	0.0	0.7	22.2	30.5	13.8	4.9	4.4	20.9	0.7	75.8	23.5
74- 80	0.0	0.0	0.0	0.0	0.7	20.5	32.4	14.6	6.0	3.4	20.6	0.7	76.9	22.4
80- 86	0.0	0.0	0.0	0.0	0.6	21.5	30.9	14.7	6.3	3.3	20.7	0.6	76.7	22.7
86- 91	0.0	0.0	0.0	0.0	0.7	22.6	31.9	14.0	5.6	3.5	21.3	0.7	77.6	21.7
91- 97	0.0	0.0	0.0	0.0	0.5	23.9	33.1	13.9	5.2	3.5	21.6	0.5	79.6	19.9
97-103	0.0	0.0	0.0	0.0	1.0	23.7	34.5	14.9	5.8	4.1	21.2	1.0	83.0	16.0
103-110	0.0	0.0	0.0	0.0	0.5	22.7	36.7	16.5	6.2	3.8	20.6	0.5	85.9	13.6
110-112	0.0	0.0	0.0	0.0	1.0	22.3	36.3	16.2	6.2	3.4	21.0	1.0	84.4	14.6
112-117	0.0	0.0	0.0	0.0	1.0	23.8	36.4	16.0	6.3	3.6	21.2	1.0	86.1	12.9
117-121	0.0	0.0	0.0	0.0	0.6	23.0	36.9	16.0	6.5	3.4	20.9	0.6	85.8	13.6
121-127	0.0	0.0	0.0	0.0	0.4	23.0	37.2	16.9	6.3	3.0	21.0	0.4	86.4	13.2
127-133	0.0	0.0	0.0	0.0	0.9	21.7	37.5	17.6	5.9	2.8	21.0	0.9	85.5	13.6
133-139	0.0	0.0	0.0	0.0	0.4	23.8	37.9	16.5	5.3	2.5	21.8	0.4	86.0	13.6
139-147	0.0	0.0	0.0	0.0	0.7	24.2	36.3	16.0	5.6	3.2	21.5	0.7	85.3	14.0
147-151	0.0	0.0	0.0	0.0	0.7	21.3	36.3	17.8	6.5	3.1	20.5	0.7	85.0	14.3
151-155	0.0	0.0	0.0	0.0	0.5	23.0	37.6	16.2	6.2	2.9	21.2	0.5	85.9	13.6
155-161	0.0	0.0	0.0	0.0	0.6	26.0	36.8	14.7	5.3	3.6	21.9	0.6	86.4	13.0
161-167	0.0	0.0	0.0	0.0	0.8	22.4	36.8	16.7	6.1	3.0	21.1	0.8	85.0	14.2

PROFILE NUMBER: 16-M15 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
167-172	0.0	0.0	0.0	0.0	0.8	27.0	36.8	14.0	5.6	2.4	22.8	0.8	85.8	13.4
172-176	0.0	0.0	0.0	0.0	1.0	27.0	36.3	14.0	5.7	2.2	23.0	1.0	85.2	13.8
176-180	0.0	0.0	0.0	0.0	2.7	27.9	34.9	14.7	5.9	2.7	23.3	2.7	86.1	11.2
180-185	0.0	0.0	0.0	0.0	1.0	25.7	35.6	14.9	6.0	2.7	22.2	1.0	84.9	14.1
185-190	0.0	0.0	0.0	0.0	1.1	27.6	35.4	13.1	5.3	2.7	23.2	1.1	84.1	14.8
190-194	0.0	0.0	0.0	0.0	1.1	26.4	36.3	13.3	5.1	3.0	22.8	1.1	84.1	14.8
194-206	0.0	0.0	0.0	0.0	1.9	29.0	35.4	12.8	5.1	2.9	23.7	1.9	85.2	12.9
206-218	0.0	0.0	0.0	0.0	1.2	25.2	35.7	13.6	5.5	2.6	22.6	1.2	82.6	16.2
218-230	0.0	0.0	0.0	0.0	1.5	26.2	36.7	12.6	5.0	2.3	23.5	1.5	82.8	15.7
230-236	0.0	0.0	0.0	0.0	0.5	18.1	40.9	19.1	7.5	3.4	19.4	0.5	89.0	10.5
236-241	0.0	0.0	0.0	0.0	0.7	23.0	37.9	14.6	5.6	2.6	21.9	0.7	83.7	15.6
241-247	0.0	0.0	0.0	0.0	0.6	25.9	35.5	14.7	4.7	2.7	22.6	0.6	83.5	15.9
247-259	0.0	0.0	0.0	0.0	1.7	16.9	37.3	19.5	7.3	3.1	19.6	1.7	84.1	14.2
259-265	0.0	0.0	0.0	0.0	0.8	17.4	39.1	18.4	6.7	2.7	19.9	0.8	84.3	14.9
265-271	0.0	0.0	0.0	0.0	0.2	15.8	38.2	20.7	7.7	2.9	18.7	0.2	85.3	14.5
271-276	0.0	0.0	0.0	0.0	0.2	12.6	36.2	25.2	10.8	4.1	16.6	0.2	88.9	11.0
276-280	0.0	0.0	0.0	0.0	0.2	14.3	38.6	24.0	9.8	3.7	17.4	0.2	90.4	9.5
280-285	0.0	0.0	0.0	0.0	0.2	15.8	37.4	23.5	9.0	3.5	17.9	0.2	89.2	10.6
285-290	0.0	0.0	0.0	0.0	0.2	9.7	34.5	27.3	11.8	4.9	15.4	0.2	88.2	11.6
290-295	0.0	0.0	0.0	0.0	0.4	9.7	29.9	30.2	13.4	5.7	14.5	0.4	88.9	10.8
295-299	0.0	0.0	0.0	0.0	0.5	9.7	34.4	28.4	13.0	5.5	15.0	0.5	91.0	8.5
299-302	0.0	0.0	0.0	0.0	0.7	9.6	27.7	30.3	14.4	6.7	14.0	0.7	88.7	10.6
302-306	0.0	0.0	0.0	0.0	1.1	11.5	29.8	27.7	11.9	5.7	15.4	1.1	86.6	12.3
306-309	0.0	0.0	0.0	0.0	1.5	14.5	26.8	24.2	11.1	6.0	16.1	1.5	82.6	15.9
309-313	0.0	0.0	0.0	0.0	0.9	18.4	20.2	22.2	11.0	6.4	16.2	0.9	78.2	20.9
313-316	0.0	0.0	0.0	0.0	0.5	15.4	17.9	21.9	11.9	7.4	14.7	0.5	74.5	25.0
316-320	0.0	0.0	0.0	0.0	0.7	15.6	18.4	21.3	11.9	8.2	14.7	0.7	75.4	23.9
320-323	0.0	0.0	0.0	0.0	0.5	9.9	22.4	20.4	11.8	7.6	13.9	0.5	72.1	27.4
323-329	0.0	0.0	0.0	0.0	0.8	10.3	21.3	20.1	12.2	8.3	13.8	0.8	72.2	27.0
329-333	0.0	0.0	0.0	0.0	0.8	10.3	22.9	18.3	10.4	6.2	15.0	0.8	68.1	31.1
333-337	0.0	0.0	0.0	0.0	0.5	8.1	15.3	15.2	9.5	6.9	13.4	0.5	55.0	44.5

PROFILE NUMBER: 16-M15 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
337-341	0.0	0.0	0.0	0.0	2.3	8.9	14.7	14.4	9.7	8.3	13.9	2.3	56.0	41.7
341-344	0.0	0.0	0.0	0.0	1.9	9.8	17.0	17.3	10.8	8.1	14.0	1.9	63.0	35.1
344-348	0.0	0.0	0.0	0.0	1.4	8.1	18.3	19.9	11.1	6.5	13.9	1.4	63.9	34.8
348-352	0.0	0.0	0.0	0.0	1.7	8.3	19.1	20.0	10.5	6.4	14.3	1.7	64.3	34.0
352-357	0.0	0.0	0.0	0.0	2.2	8.9	20.0	18.7	9.9	6.0	15.0	2.2	63.5	34.3
357-362	0.0	0.0	0.0	0.0	3.7	9.3	19.7	18.5	9.6	5.2	16.1	3.7	62.3	34.0
362-367	0.0	0.0	0.0	0.0	4.1	8.0	18.7	17.7	8.9	5.1	16.2	4.1	58.4	37.5

PROFILE NUMBER: 16-M18

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 5		3.0	76.0	21.0	7.1	99.8		2.89		3.2	18.8	0.90
5- 10		2.4	75.4	21.2	7.2	52.6		2.10		3.2	19.0	0.90
10- 14		1.5	75.6	22.9	7.1	19.2		1.83		4.4	19.9	0.87
14- 19		1.3	72.0	26.7	6.9	14.0		1.65		5.2	18.3	0.69
19- 23		1.2	71.1	27.7	6.9	7.8		1.22		5.6	18.3	0.66
23- 29		1.1	71.7	27.2	6.4	7.3		0.92		7.2	17.3	0.64
29- 34		1.2	70.9	28.0	5.7	9.6		0.51		7.6	19.9	0.71
34- 39		1.0	73.5	25.5	5.7	21.7		0.27		6.8	20.0	0.78
39- 43		1.2	73.4	25.4	5.9	34.0		0.20		6.0	19.1	0.75
43- 47		1.6	72.7	25.7	6.0	39.9		0.16		6.0	21.3	0.83
47- 52		3.3	73.5	23.2	5.9	37.0		0.09		5.6	18.9	0.81
52- 56		7.9	67.5	24.6	5.8	36.0		0.08		5.6	18.7	0.76
56- 57		75.9	11.7	12.4	5.9	26.8		0.08		3.2		
57- 62		6.2	71.3	22.5	5.8	31.0		0.03		4.0		
62- 67		10.0	67.9	22.1	5.8	29.2		0.08		3.1		
67- 72		23.9	56.9	19.2	5.8	27.2		0.09		2.2		
72- 75		62.6	26.1	11.3	6.0	20.3		0.15		0.4		
75- 77		49.2	36.8	14.0	5.9	25.0		0.09		0.9		
77- 79		67.5	21.8	10.7	6.2	21.4		0.11		0.9		
79- 81		85.0	9.4	5.6	6.4	8.8		0.11		0.9		
81- 85		87.4	5.8	6.8	6.2	15.5		0.09				
85- 87		62.0	27.1	10.9	6.4	15.8		0.23		0.4		
87- 92		89.1	5.1	5.8	6.3	16.4		0.18				
92- 93		59.8	30.4	9.8	6.3	13.5		0.16				
93- 97		90.1	5.3	4.6	6.8	11.7		0.12				
97- 99		54.3	34.0	11.7	6.2	11.4		0.06				
99-109		49.5	39.8	10.7	6.5	10.2		0.13				
109-114	2.2	44.8	34.3	20.9	6.9	5.0						
114-119	4.1	40.4	36.2	23.4	6.7	5.2						
119-123	4.1	38.3	36.7	25.0	6.7	5.6						
123-127	2.1	38.7	36.5	24.8	6.7	8.1						

PROFILE NUMBER: 16-M18 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
127-132	1.7	39.3	37.6	23.1	7.2	2.5			0.52			
132-138	2.6	42.4	39.0	18.6	7.6	1.6			1.23			

PROFILE NUMBER: 16-M21

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		2.1	70.9	27.0	6.9	44.5		1.88		4.6	25.6	0.95
7- 10		1.9	71.0	27.1	6.9	41.0		1.93		3.8	24.4	0.90
10- 13		1.6	68.0	30.4	6.7	10.8		1.47		5.5	25.0	0.82
13- 17		1.3	66.4	32.3	6.5	7.5		1.01		5.9	23.1	0.72
17- 21		1.2	64.6	34.2	5.9	7.0		0.59		6.7	22.3	0.65
21- 25		1.3	65.5	33.2	5.7	16.9		0.30		6.3	24.6	0.74
25- 29		1.8	66.7	31.5	5.6	30.0		0.24		5.5	24.8	0.79
29- 35		1.3	68.2	30.5	5.7	32.0		0.16		5.5	26.8	0.88
35- 39		0.8	70.6	28.6	5.8	28.8		0.16		4.2	28.0	0.98
39- 43		1.1	72.1	26.8	5.8	24.5				4.2	28.5	1.06
43- 49		1.1	73.6	25.3	6.3	14.7				2.5	24.2	0.96
49- 55		1.0	74.9	24.1	6.8	10.0				1.7	22.6	0.94
55- 61		1.0	76.3	22.7	7.1	7.0				0.4	20.0	0.88
61- 67		1.2	82.4	16.4	7.6	2.3						
67- 72		1.5	82.1	16.4	7.7	2.0			10.14			
72- 78		1.9	81.6	16.5	7.7	3.8			9.77			
78- 84		1.8	82.5	15.7	7.7	2.3			10.79			
84- 90		2.3	82.7	15.0	7.8	2.5			11.94			
90- 96		4.7	80.0	15.3	7.8	2.5			11.44			
96-102		1.5	85.1	13.4	7.7	2.0			12.53			
102-108		1.3	85.1	13.6	7.8							
108-114		0.8	84.6	14.6	7.9							
114-120		1.5	84.9	13.6	7.8							
120-126		0.7	87.3	12.0	8.0							
126-132		1.0	84.2	14.8	7.6							
132-138		0.9	84.6	14.5	7.9							
138-144		1.4	83.8	14.8	7.9							
144-150		1.1	83.7	15.2	7.9							
150-156		0.8	83.7	15.5	7.9							
156-160		0.7	83.9	15.4	7.9							
160-164		0.8	83.5	15.7	7.9							

PROFILE NUMBER: 16-M21 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
164-166		0.7	86.5	12.8	7.8							
166-170		0.7	83.9	15.4	7.8							
170-176		2.9	82.0	15.1	7.9							
176-183		22.9	63.6	13.5	7.8							
183-189		46.5	35.3	18.2	7.7							
189-195		22.3	44.7	33.0	7.5							
195-198		41.1	35.0	23.9	7.4							
198-202		40.6	34.4	25.0	6.7							
202-208		38.1	35.8	26.1	6.9							
208-214		37.6	36.2	26.2	6.7							
214-220		38.4	35.1	26.5	7.6							
220-226		38.1	37.4	24.5	7.9							
226-231		36.7	37.1	26.2	7.7							

PROFILE NUMBER: 16-N24

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 8		2.7	74.1	23.2	6.1	28.4		2.15				
8- 11		3.1	72.3	24.6	6.1	13.6		1.35				
11- 14		4.2	70.0	25.8	5.7	6.8		1.14				
14- 17		3.8	68.7	27.5	5.5	5.8		0.71				
17- 21		2.2	65.5	32.3	5.4	6.7		0.56				
21- 28		1.1	62.7	36.2	5.3	17.4		0.23				
28- 32		1.5	62.2	36.3	5.4	28.2		0.15				
32- 36		0.9	63.4	35.7	5.6	34.0		0.11				
36- 41		2.5	64.2	33.3	5.9	24.3						
41- 48		1.9	67.1	31.0	5.9	20.0						
48- 52		1.9	69.8	28.3	6.0	16.3						
52- 56		1.0	72.5	26.5	6.2	16.0						
56- 62		1.3	73.5	25.2	6.2	15.5						
62- 68		1.1	76.1	22.8	6.3	17.2						
68- 73		1.0	75.3	23.7	6.4	13.8						
73- 77		1.2	75.7	23.1	6.6	12.7						
77- 82		1.4	76.2	22.4	6.8	9.3						
82- 87		0.9	79.9	19.2	7.1	5.2						
87- 92		1.1	81.6	17.3	7.4	7.2						
92- 97		1.1	83.1	15.8	7.6	4.8						
97-102		1.0	84.3	14.7	7.9	4.0						
102-107		0.8	84.9	14.3	7.9	3.9						
107-111		1.1	83.7	15.2	7.9	4.0						
111-117		0.9	86.5	12.6	7.9	4.9						
117-123		1.0	84.4	14.6	7.9	3.2						
123-129		1.3	86.1	12.6	8.0	2.5						
129-134		1.1	90.1	8.8	7.8	3.2						
134-138		1.2	87.2	11.6	7.8	2.9						
138-141		0.8	84.8	14.4	8.0	4.0						
141-147		1.1	85.1	13.8	8.0	3.5						
147-152		0.6	84.3	15.2	8.0	3.2						

PROFILE NUMBER: 16-M24 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
152-156		1.3	84.2	14.5	7.7	2.5						
156-160		2.3	82.5	15.2	7.9	2.3						
160-164		2.6	82.9	14.5	7.9	3.2						
164-170		7.0	79.7	13.3	8.0	1.9						
170-176		5.7	78.7	15.6	7.7	2.8						
176-182		11.4	71.0	17.6	7.5	2.5						
182-188		12.7	69.8	17.5	7.6	2.5						
188-194		15.4	65.0	19.6	7.7	4.3						
194-200		13.7	66.1	20.2	7.6	4.1						
200-206		16.0	67.0	17.0	7.6	3.4						
206-212		6.7	76.8	16.5	7.6	2.0						
212-218		11.9	70.2	17.9	7.7	3.9						
218-224		15.7	65.0	19.3	7.7	3.2						
224-230		12.9	69.7	17.4	7.7	3.2						
230-236		5.1	79.1	15.8	7.3	2.3						
236-242		1.7	85.9	12.4	7.4	1.9						
242-248		0.6	88.5	10.9	7.3	3.9						
248-254		0.6	87.5	11.9	7.5	2.3						
254-260		0.6	86.8	12.6	7.5	3.3						
260-264		0.9	86.4	12.7	7.3	2.3						
264-268		1.0	85.3	13.7	7.5	3.0						
268-274		0.7	87.8	11.5	7.5	2.5						
274-278		0.8	89.6	9.6	7.6	2.3						
278-282		0.6	89.6	9.8	7.4	3.2						
282-285		0.5	90.0	9.5	7.1	4.4						
285-289		1.0	79.1	19.9	7.1	6.4						
289-293		1.2	84.3	14.5	7.4	5.3						
293-297		1.0	88.4	10.7	7.4	5.3						
297-302		1.5	71.0	27.5	6.7	6.9						
302-306		1.2	69.5	29.3	6.7	6.5						
306-310		0.9	64.1	35.0	6.8	5.8						
310-314		1.1	64.7	34.2	7.0	6.9						

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PROFILE NUMBER: 16-N26

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 8		0.8	72.4	26.8	7.3	19.7	39.0	1.66		2.8		
8- 12		0.7	70.0	29.3	7.0	7.3	8.0	0.98		4.0		
12- 15		0.6	68.8	30.6	6.9	4.5	5.0	0.74		4.4		
15- 18		0.6	68.0	31.4	6.8	2.9	4.0	0.73		4.4		
18- 21		0.7	67.9	31.4	6.6	3.5	4.0	0.97		4.4		
21- 26		0.9	68.7	30.4	6.5	5.7	8.0	0.34		5.2		
26- 30		1.3	67.6	31.1	5.9	10.6	17.0	0.42		5.6		
30- 34		1.3	69.6	29.1	5.7	16.9	22.0	0.23		5.6		
34- 39		1.2	68.9	29.9	5.8	19.7	36.0	0.15		5.2		
39- 44		1.2	69.3	29.5	6.0	19.4	52.0			4.4		
44- 50		0.7	72.3	27.0	6.4	19.6	80.0			4.0		
50- 56		0.7	73.9	25.4	6.4	17.5	94.0			3.6		
56- 62		0.5	76.3	23.2	6.2	17.3	114.0			3.2		
62- 68		0.6	77.0	22.4	6.5	17.1				2.8		
68- 74		0.4	77.8	21.8	6.3	17.9				2.8		
74- 80		0.5	78.8	20.7	6.3	21.0						
80- 86		0.4	78.6	21.0	6.6	18.2	136.0					
86- 92		0.4	80.4	19.2	6.5	21.0	104.0					
92- 98		4.0	77.5	18.5	6.7	19.5	56.0					
98-102		19.2	64.0	16.8	7.1	16.5	102.0	0.09				
102-106		13.6	71.8	14.6	7.6	12.3	126.0	0.25	1.29			
106-107		36.8	50.8	12.4	8.0	10.2	104.0					
107-113		11.9	73.1	15.0	7.9	11.5	154.0	0.46	4.27			
113-119		4.6	80.1	15.3	7.9	10.0	94.0	0.49	3.92			
119-126		11.5	71.0	17.5	8.0	9.5	88.0	0.40	2.09			
126-132		57.0	24.9	18.1	7.9	7.0	28.0	0.10	4.97			
132-138		56.2	24.4	19.4	7.8	6.5	24.0	0.09				
138-142		55.0	24.3	20.7	7.8	5.4	30.0	0.02	0.70			
142-146		58.2	20.9	20.9	7.8	4.6	16.0	0.03	0.71			
146-150		60.4	21.8	17.8	7.8	5.0	20.0	0.18	0.43			
150-155		43.2	35.6	21.2	7.8	6.0	16.0	0.08	1.30			

PROFILE NUMBER: 16-M26 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
157-163		24.2	55.9	19.9	7.9	6.9	50.0	0.26	2.60			
163-169		21.7	58.8	19.5	8.0	5.8	48.0	0.29	2.32			
169-174		65.6	18.8	15.6	8.0	3.8	17.8	0.14	1.14			
174-178		51.2	28.9	19.9	7.9	5.6	33.5	0.16	1.20			
178-184		18.9	61.3	19.8	7.7	7.0	43.4	0.18	4.70			
184-189		12.4	67.6	20.0	8.0	4.8	53.4	0.42	4.14			
189-193		0.6	84.1	15.3	7.9	6.2	66.0	0.54	7.80			
193-198		2.2	82.6	15.2	7.8		80.0	1.12	7.05			
198-205		0.6	86.7	12.7	8.0	4.2	64.4	1.01	9.30			
205-212		0.4	88.1	11.5	7.9	3.2	51.2	1.07	10.51			
212-218		0.2	90.7	9.1	8.0	1.8	18.0	0.94	13.72			
218-222		0.3	88.4	11.3	7.7	2.4	30.5	1.14	10.28			
222-228		0.6	86.2	13.2	7.7	3.2	37.0	1.19	8.59			
228-234		0.5	86.5	13.0	7.8	3.0	20.0	1.25	8.29			
234-240		0.5	92.4	7.1	7.7	1.8	9.0	1.50	11.26			
240-246		0.8	92.3	6.9	7.8	2.0	5.0	1.44	13.27			
246-252		0.4	92.3	7.3	7.8	3.0	6.5	1.26	9.11			
252-258		0.5	90.0	9.5	7.7	3.0	8.0	1.16	7.68			
258-264		0.4	85.3	14.3	7.7	7.8	32.5	0.49	1.50			
264-268		0.4	84.1	15.5	7.7	6.5	42.5	0.34	0.89			
268-272		0.4	79.3	20.3	7.2	5.6	36.6	0.31				
272-278		0.6	75.9	23.5	6.9	4.2	25.5	0.29				
278-282		0.6	71.6	27.8	6.9	2.2	21.0	0.19				
282-286		0.5	69.1	30.4	7.2	1.4	13.5	0.18				
286-290		0.5	70.1	29.4	7.3	2.0	8.0	0.26				
290-294		0.8	66.0	33.2	7.4	1.0	6.5	0.26	0.91			
294-298		0.4	58.8	40.8	7.4	1.0	1.5	0.22				

PROFILE NUMBER: 16-M26

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 8	0.0	0.0	0.0	0.0	0.8	18.1	26.6	15.8	7.6	4.3	18.8	0.8	72.4	26.8
8- 12	0.0	0.0	0.0	0.0	0.7	16.7	25.3	15.6	7.8	4.6	18.2	0.7	70.0	29.3
12- 15	0.0	0.0	0.0	0.0	0.6	17.5	25.3	14.6	7.2	4.2	18.8	0.6	68.8	30.6
15- 18	0.0	0.0	0.0	0.0	0.6	16.8	25.4	14.3	7.4	4.1	18.7	0.6	68.0	31.4
18- 21	0.0	0.0	0.0	0.0	0.7	17.2	26.0	14.4	6.5	3.8	19.3	0.7	67.9	31.4
21- 26	0.0	0.0	0.0	0.0	0.9	16.5	26.3	14.2	7.2	4.5	18.6	0.9	68.7	30.4
26- 30	0.0	0.0	0.0	0.0	1.3	17.7	25.6	13.2	7.0	4.1	19.5	1.3	67.6	31.1
30- 34	0.0	0.0	0.0	0.0	1.3	21.1	27.4	11.4	5.8	3.9	21.2	1.3	69.6	29.1
34- 39	0.0	0.0	0.0	0.0	1.2	19.8	26.4	12.2	6.5	4.0	20.3	1.2	68.9	29.9
39- 44	0.0	0.0	0.0	0.0	1.2	19.4	27.2	12.6	6.3	3.8	20.4	1.2	69.3	29.5
44- 50	0.0	0.0	0.0	0.0	0.7	21.3	27.9	13.3	6.2	3.6	20.7	0.7	72.3	27.0
50- 56	0.0	0.0	0.0	0.0	0.7	20.8	28.9	13.7	6.6	3.9	20.3	0.7	73.9	25.4
56- 62	0.0	0.0	0.0	0.0	0.5	22.5	29.8	14.3	6.3	3.4	20.9	0.5	76.3	23.2
62- 68	0.0	0.0	0.0	0.0	0.6	23.0	30.0	14.4	6.4	3.2	21.1	0.6	77.0	22.4
68- 74	0.0	0.0	0.0	0.0	0.4	24.0	29.4	14.8	6.1	3.5	21.1	0.4	77.8	21.8
74- 80	0.0	0.0	0.0	0.0	0.5	23.8	31.7	13.6	6.3	3.4	21.3	0.5	78.8	20.7
80- 86	0.0	0.0	0.0	0.0	0.4	21.7	31.7	15.3	6.5	3.4	20.5	0.4	78.6	21.0
86- 92	0.0	0.0	0.0	0.0	0.4	20.3	34.5	15.8	6.6	3.2	20.3	0.4	80.4	19.2
92- 98	0.0	0.3	0.9	1.1	1.7	24.5	31.7	13.2	5.3	2.8	24.4	4.0	77.5	18.5
98-102	0.0	0.7	7.2	5.7	5.6	28.9	22.4	7.5	3.3	1.9	41.9	19.2	64.0	16.8
102-106	0.0	0.6	4.5	4.0	4.5	28.8	26.5	10.0	4.2	2.3	34.0	13.6	71.8	14.6
106-107	0.0	1.5	13.4	13.1	8.8	22.0	18.7	6.3	2.6	1.2	63.0	36.8	50.8	12.4
107-113	0.0	0.1	2.5	5.4	3.9	25.3	29.4	11.3	4.8	2.3	30.5	11.9	73.1	15.0
113-119	0.0	0.2	1.2	1.1	2.1	29.4	31.5	12.1	4.4	2.7	26.3	4.6	80.1	15.3
119-126	0.2	1.2	3.1	3.0	4.0	28.1	27.6	9.5	3.8	2.0	33.3	11.5	71.0	17.5
126-132	0.7	10.1	31.2	12.0	3.0	7.2	7.7	5.3	3.1	1.6	141.8	57.0	24.9	18.1
132-138	0.2	5.7	30.6	15.9	3.8	7.6	6.3	5.7	3.0	1.8	128.9	56.2	24.4	19.4
138-142	0.4	4.1	30.4	15.3	4.8	6.6	7.0	6.0	2.9	1.8	123.0	55.0	24.3	20.7
142-146	0.7	13.7	30.4	10.5	2.9	6.2	5.5	5.0	2.5	1.7	165.3	58.2	20.9	20.9
146-150	0.7	12.4	28.9	15.5	2.9	5.8	6.3	5.3	2.6	1.8	155.3	60.4	21.8	17.8

PROFILE NUMBER: 16-M26 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
150-155	0.5	9.5	19.3	9.3	4.6	13.1	10.0	7.0	3.7	1.8	94.4	43.2	35.6	21.2
157-163	0.2	2.2	8.5	7.6	5.7	22.1	20.1	8.4	3.6	1.7	47.7	24.2	55.9	19.9
163-169	0.2	1.2	6.4	6.5	7.4	26.8	18.6	7.8	3.6	2.0	44.0	21.7	58.8	19.5
169-174	1.2	11.2	33.0	16.1	4.1	5.9	5.2	4.0	2.2	1.5	175.1	65.6	18.8	15.6
174-178	0.6	7.0	30.5	9.9	3.2	10.3	7.6	5.8	3.3	1.9	120.5	51.2	28.9	19.9
178-184	0.1	0.7	6.7	5.9	5.5	24.5	22.2	8.8	3.6	2.2	40.0	18.9	61.3	19.8
184-189	0.1	1.0	5.6	2.9	2.8	21.7	26.6	11.9	4.7	2.7	31.8	12.4	67.6	20.0
189-193	0.0	0.0	0.0	0.0	0.6	19.0	38.6	17.7	6.0	2.8	20.4	0.6	84.1	15.3
193-198	0.0	0.0	0.0	0.0	2.2	32.1	32.2	11.8	4.6	1.9	25.5	2.2	82.6	15.2
198-205	0.0	0.0	0.0	0.0	0.6	15.4	38.1	21.9	7.8	3.5	18.4	0.6	86.7	12.7
205-212	0.0	0.0	0.0	0.0	0.4	14.5	38.8	22.7	8.6	3.5	18.0	0.4	88.1	11.5
212-218	0.0	0.0	0.0	0.0	0.2	16.1	40.6	22.8	7.9	3.3	18.5	0.2	90.7	9.1
218-222	0.0	0.0	0.0	0.0	0.3	14.1	38.4	23.3	8.7	3.9	17.6	0.3	88.4	11.3
222-228	0.0	0.0	0.0	0.0	0.6	17.7	38.0	19.4	7.7	3.4	19.2	0.6	86.2	13.2
228-234	0.0	0.0	0.0	0.0	0.5	18.2	37.6	19.6	7.4	3.7	19.2	0.5	86.5	13.0
234-240	0.0	0.0	0.0	0.0	0.5	14.7	39.0	24.8	9.4	4.5	17.4	0.5	92.4	7.1
240-246	0.0	0.0	0.0	0.0	0.8	16.6	41.9	22.7	7.6	3.5	18.9	0.8	92.3	6.9
246-252	0.0	0.0	0.0	0.0	0.4	13.0	42.9	23.6	8.6	4.2	17.6	0.4	92.3	7.3
252-258	0.0	0.0	0.0	0.0	0.5	13.9	34.2	25.2	11.1	5.6	16.2	0.5	90.0	9.5
258-264	0.0	0.0	0.0	0.0	0.4	11.7	30.4	24.0	12.2	7.0	15.0	0.4	85.3	14.3
264-268	0.0	0.0	0.0	0.0	0.4	10.9	30.4	22.8	13.0	7.0	14.7	0.4	84.1	15.5
268-272	0.0	0.0	0.0	0.0	0.4	10.8	25.9	22.6	12.7	7.3	14.3	0.4	79.3	20.3
272-278	0.0	0.0	0.0	0.0	0.6	10.3	24.7	21.3	12.1	7.5	14.2	0.6	75.9	23.5
278-282	0.0	0.0	0.0	0.0	0.6	9.5	23.2	20.9	11.3	6.7	14.3	0.6	71.6	27.8
282-286	0.0	0.0	0.0	0.0	0.5	9.2	21.6	19.6	11.6	7.1	13.9	0.5	69.1	30.4
286-290	0.0	0.0	0.0	0.0	0.5	9.7	21.4	19.6	11.9	7.5	13.8	0.5	70.1	29.4
290-294	0.0	0.0	0.0	0.0	0.8	11.3	18.9	16.7	10.8	8.3	14.1	0.8	66.0	33.2
294-298	0.0	0.0	0.0	0.0	0.4	10.8	13.6	15.7	9.2	9.5	13.1	0.4	58.8	40.8

PROFILE NUMBER: 16-M27

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		0.9	71.6	27.5	6.8	39.5		1.76				
6- 8		0.8	71.2	28.0	6.9	46.5		1.75				
8- 11		0.7	70.8	28.5	6.8	12.0		1.00				
11- 16		0.7	70.4	28.9	6.6	5.0		0.52				
16- 21		0.7	68.5	30.8	6.3	9.5		0.24				
21- 26		0.7	67.1	32.2	5.9	16.5		0.22				
26- 30		0.9	69.3	29.8	5.8	21.5		0.15				
30- 36		0.6	72.8	26.6	5.9	20.0		0.10				
36- 42		0.6	74.2	25.2	5.9	16.5		0.07				
42- 48		0.5	74.3	25.2	5.9	17.5		0.08				
48- 54		0.4	75.4	24.2	6.3	16.5		0.14				
54- 60		0.4	75.8	23.8	6.1	17.0						
60- 66		0.3	77.2	22.5	6.1	22.0						
66- 72		0.5	78.3	21.2	6.2	18.4						
72- 78		0.5	77.2	22.3	6.0	20.0						
78- 84		2.9	76.3	20.8	6.1	23.0						
84- 90		15.7	65.1	19.2	6.1	23.0						
90- 92		12.5	67.7	19.8	6.1	23.0						
92- 95		23.9	57.2	18.9	6.2	20.0						
95- 98		25.5	57.0	17.5	6.3	22.0						
98-100		44.5	38.8	16.7	6.3	21.0						
100-104		11.2	70.6	18.2	6.4	23.0						
104-108		15.1	67.2	17.7	6.4	24.0						
108-110		14.9	67.4	17.7	6.6	23.5						

PRCFILE NUMBER: 16-M28

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.0	72.7	26.3	7.2	40.5		2.07		3.2		
6- 8		0.8	72.3	26.9	7.1	36.0		1.89		4.0		
8- 11		0.8	70.4	28.8	6.8	6.0		1.03		4.0		
11- 15		0.7	69.0	30.3	6.6	6.3		0.74		4.0		
15- 19		0.8	69.7	29.5	6.4	4.6		0.83		4.4		
19- 23		0.9	69.7	29.4	5.8	7.5		0.57		5.2		
23- 26		0.8	69.6	29.6	5.7	15.0		0.41		6.4		
26- 29		1.1	69.5	29.4	5.5	20.0		0.36		6.0		
29- 32		1.1	69.7	29.2	5.7	26.5		0.34		6.0		
32- 35		0.8	70.1	29.1	5.7	33.7		0.20		6.0		
35- 41		0.9	70.3	28.8	5.6	42.5				5.6		
41- 47		0.8	72.3	26.9	5.6	40.5				4.8		
47- 53		0.7	74.8	24.5	5.7	40.5				4.4		
53- 59		0.7	74.9	24.4	5.8	44.3				4.8		
59- 65		0.6	74.4	25.0	5.7	44.3						
65- 71		0.6	75.2	24.2	5.7	41.5						
71- 77		0.5	75.8	23.7	5.7	38.5						
77- 83		0.4	75.8	23.8	5.9	33.0						
83- 89		0.6	76.4	23.0	5.9	31.0						
89- 95		0.4	77.1	22.5	6.1	27.6						
95-101		0.4	78.0	21.6	6.2	29.2						
101-107		0.4	77.6	22.0	6.3							
107-114		2.9	75.9	21.2	6.5							
114-120		0.8	79.8	19.4	6.7							
120-122		27.9	57.9	14.2	7.6							
122-128		4.2	80.2	15.6	7.8							
128-134		3.2	83.6	13.2	7.7							
134-140		1.5	84.5	14.0	7.6							
140-146		3.4	82.2	14.4	7.7							
146-151		9.9	75.7	14.4	7.9							
151-155		8.1	77.4	14.5	7.8							

PROFILE NUMBER: 16-M28 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
155-156		29.0	57.7	13.3	7.8							
156-160		27.6	58.3	14.1	7.6							
160-166		41.1	45.5	13.4	7.5							
166-171		41.2	45.3	13.5	7.7							
171-176		57.9	29.9	12.2	7.4							
176-182		61.3	28.3	10.4	7.3							
182-190		65.4	25.5	9.1	6.9							
190-193		75.4	17.1	7.5	6.9							
193-199		72.9	19.3	7.8	7.5							
199-205		87.3	7.5	5.2	7.6							
205-211		83.6	10.5	5.9	7.7							
211-217		81.8	11.9	6.3	7.6							
217-223		82.4	11.1	6.5	7.7							
223-230		80.2	13.2	6.6	7.7							
230-236		55.5	32.7	11.8	7.7		60.0	0.57	4.72			
236-238		20.6	63.5	15.9	7.8		53.0	1.12	9.30			
238-244		11.7	70.4	17.9	7.9		43.5	1.21	10.06			
244-250		8.9	74.2	16.9	7.8		44.0	1.39	11.62			
250-254		13.6	66.2	20.2	7.9		63.0	1.20	10.04			
254-259		17.6	60.1	22.3	7.9		49.0	1.01	8.44			
259-264		17.5	60.6	21.9	7.9		54.0	0.40	4.95			
264-267		10.1	69.4	20.5	7.9	4.8	65.0	0.47	7.45			
267-270		12.4	52.6	35.0	8.2	6.8	29.0	0.04	1.30			
270-275		19.3	44.2	36.5	8.1	6.8	20.0	0.03				
275-279		18.0	43.8	38.2	7.7	8.0						
279-284		19.2	43.1	37.7	7.6	5.3						
284-290		18.3	47.2	34.5	7.6	0.8						
290-296		25.8	40.7	33.5	7.4	1.3						
296-304		33.8	35.2	31.0	7.2	4.3						

PROFILE NUMBER: 16-M28

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 6	0.0	0.0	0.0	0.0	1.0	18.9	24.9	16.3	7.8	4.8	18.6	1.0	72.7	26.3
6- 8	0.0	0.0	0.0	0.0	0.8	18.6	24.7	16.0	8.3	4.7	18.4	0.8	72.3	26.9
8- 11	0.0	0.0	0.0	0.0	0.8	17.1	25.3	14.9	8.3	4.8	18.1	0.8	70.4	28.8
11- 15	0.0	0.0	0.0	0.0	0.7	15.3	25.1	16.8	6.6	5.2	17.7	0.7	69.0	30.3
15- 19	0.0	0.0	0.0	0.0	0.8	16.3	25.5	15.9	6.9	5.1	18.1	0.8	69.7	29.5
19- 23	0.0	0.0	0.0	0.0	0.9	17.5	25.4	15.4	6.8	4.6	18.8	0.9	69.7	29.4
23- 26	0.0	0.0	0.0	0.0	0.8	18.9	25.6	14.4	6.5	4.2	19.5	0.8	69.6	29.6
26- 29	0.0	0.0	0.0	0.0	1.1	20.5	26.7	13.1	5.6	3.6	20.9	1.1	69.5	29.4
29- 32	0.0	0.0	0.0	0.0	1.1	23.0	25.9	12.1	5.0	3.7	21.8	1.1	69.7	29.2
32- 35	0.0	0.0	0.0	0.0	0.8	20.2	27.2	13.1	5.8	3.8	20.5	0.8	70.1	29.1
35- 41	0.0	0.0	0.0	0.0	0.9	20.7	26.7	13.8	5.2	3.9	20.7	0.9	70.3	28.8
41- 47	0.0	0.0	0.0	0.0	0.8	20.2	29.6	14.4	4.9	3.2	21.0	0.8	72.3	26.9
47- 53	0.0	0.0	0.0	0.0	0.7	23.5	29.4	14.1	4.8	3.0	21.9	0.7	74.8	24.5
53- 59	0.0	0.0	0.0	0.0	0.7	22.6	30.1	14.2	5.1	2.9	21.7	0.7	74.9	24.4
59- 65	0.0	0.0	0.0	0.0	0.6	21.3	29.8	14.6	5.2	3.5	20.9	0.6	74.4	25.0
65- 71	0.0	0.0	0.0	0.0	0.6	21.7	29.5	15.0	5.5	3.5	20.8	0.6	75.2	24.2
71- 77	0.0	0.0	0.0	0.0	0.5	22.2	30.1	14.6	5.6	3.3	21.0	0.5	75.8	23.7
77- 83	0.0	0.0	0.0	0.0	0.4	21.8	30.0	15.1	5.3	3.6	20.8	0.4	75.8	23.8
83- 89	0.0	0.0	0.0	0.0	0.6	22.7	30.2	15.1	5.1	3.3	21.3	0.6	76.4	23.0
89- 95	0.0	0.0	0.0	0.0	0.4	22.2	31.3	14.9	5.5	3.2	21.1	0.4	77.1	22.5
95-101	0.0	0.0	0.0	0.0	0.4	22.8	31.8	15.0	5.5	2.9	21.4	0.4	78.0	21.6
101-107	0.0	0.0	0.0	0.0	0.4	22.0	32.1	15.0	5.5	3.0	21.2	0.4	77.6	22.0
107-114	0.0	0.0	0.0	0.0	2.9	22.0	31.4	14.5	5.1	2.9	22.4	2.9	75.9	21.2
114-120	0.0	0.0	0.0	0.0	0.8	22.7	33.1	14.7	5.8	3.5	21.2	0.8	79.8	19.4
120-122	0.0	0.1	9.8	11.5	6.5	21.7	22.0	7.3	4.4	2.5	46.8	27.9	57.9	14.2
122-128	0.0	0.2	1.3	1.4	1.3	22.0	34.0	14.8	6.2	3.2	23.2	4.2	80.2	15.6
128-134	0.0	0.1	0.6	1.5	1.0	23.3	36.0	14.9	5.9	3.5	22.7	3.2	83.6	13.2
134-140	0.0	0.0	0.0	0.0	1.5	22.8	37.6	15.1	5.6	3.4	21.6	1.5	84.5	14.0
140-146	0.0	0.0	0.0	0.0	3.4	23.2	35.5	14.9	5.4	3.2	22.6	3.4	82.2	14.4
146-151	0.0	0.6	4.2	3.1	2.0	22.9	31.6	13.4	5.2	2.6	28.7	9.9	75.7	14.4

PROFILE NUMBER: 16-M28 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
151-155	0.1	0.4	2.8	3.2	1.6	23.1	32.5	13.4	5.3	3.1	26.9	8.1	77.4	14.5
155-156	0.2	1.9	14.6	7.0	5.3	21.3	22.3	8.7	1.6	3.8	51.7	29.0	57.7	13.3
156-160	0.0	0.0	0.0	0.0	27.6	21.0	22.4	9.7	3.1	2.1	36.3	27.6	58.3	14.1
160-166	0.3	2.7	21.1	10.7	6.3	21.0	14.8	5.4	2.6	1.7	77.8	41.1	45.5	13.4
166-171	0.5	3.5	21.5	9.9	5.8	45.3	0.0	0.0	0.0	0.0	109.7	41.2	45.3	13.5
171-176	0.1	4.4	25.0	19.0	9.4	29.9	0.0	0.0	0.0	0.0	141.7	57.9	29.9	12.2
176-182	0.1	7.3	32.2	14.6	7.1	28.3	0.0	0.0	0.0	0.0	164.5	61.3	28.3	10.4
182-190	0.4	6.2	30.4	19.7	8.7	25.5	0.0	0.0	0.0	0.0	165.9	65.4	25.5	9.1
190-193	1.1	13.6	28.2	24.9	7.6	17.1	0.0	0.0	0.0	0.0	212.5	75.4	17.1	7.5
193-199	0.1	5.9	40.9	19.0	7.0	19.3	0.0	0.0	0.0	0.0	197.9	72.9	19.3	7.8
199-205	0.2	13.7	49.4	20.0	4.0	7.5	0.0	0.0	0.0	0.0	287.2	87.3	7.5	5.2
205-211	0.5	14.8	40.4	22.6	5.3	10.5	0.0	0.0	0.0	0.0	261.3	83.6	10.5	5.9
211-217	0.4	16.7	43.9	16.0	4.8	11.9	0.0	0.0	0.0	0.0	270.9	81.8	11.9	6.3
217-223	0.1	5.0	40.4	29.6	7.3	11.1	0.0	0.0	0.0	0.0	219.2	82.4	11.1	6.5
223-230	0.2	5.8	36.4	29.9	7.9	13.2	0.0	0.0	0.0	0.0	208.2	80.2	13.2	6.6
230-236	0.0	1.5	18.5	27.8	7.7	32.7	0.0	0.0	0.0	0.0	124.6	55.5	32.7	11.8
236-238	0.2	2.6	8.3	6.2	3.3	63.5	0.0	0.0	0.0	0.0	71.5	20.6	63.5	15.9
238-244	0.0	0.5	3.3	4.3	3.6	70.4	0.0	0.0	0.0	0.0	57.1	11.7	70.4	17.9
244-250	0.0	0.7	3.0	2.6	2.6	74.2	0.0	0.0	0.0	0.0	54.8	8.9	74.2	16.9
250-254	0.1	0.8	4.5	4.6	3.6	66.2	0.0	0.0	0.0	0.0	60.4	13.6	66.2	20.2
254-259	0.0	0.0	0.0	0.0	17.6	20.9	21.7	9.8	4.9	2.8	30.2	17.6	60.1	22.3
259-264	0.0	0.0	0.0	0.0	17.5	19.2	23.2	10.5	4.4	3.3	29.4	17.5	60.6	21.9
264-267	0.0	0.0	0.0	0.0	10.1	16.5	27.9	15.1	6.2	3.7	23.2	10.1	69.4	20.5
267-270	0.0	0.0	0.0	0.0	12.4	13.2	16.9	12.0	6.4	4.1	23.8	12.4	52.6	35.0
270-275	0.0	0.0	0.0	0.0	19.3	12.6	13.6	9.9	4.4	3.7	29.8	19.3	44.2	36.5
275-279	0.0	0.0	0.0	0.0	18.0	12.2	13.3	7.7	7.2	3.4	28.2	18.0	43.8	38.2
279-284	0.0	0.0	0.0	0.0	19.2	12.9	13.0	8.9	5.1	3.2	30.3	19.2	43.1	37.7
284-290	0.0	0.0	0.0	0.0	18.3	12.9	14.6	10.0	6.0	3.7	28.0	18.3	47.2	34.5
290-296	0.0	0.0	0.0	0.0	25.8	13.2	11.3	8.4	4.5	3.3	34.8	25.8	40.7	33.5
296-304	0.0	0.0	0.0	0.0	33.8	12.4	9.2	6.3	4.1	3.2	41.2	33.8	35.2	31.0

PROFILE NUMBER: 16-M29

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 6		1.1	71.4	27.5	6.9	50.0		1.63		4.8		
6- 9		0.8	70.6	28.6	6.7	7.2		0.73		5.2		
9- 13		0.9	69.3	29.8	6.5	6.2		0.46		5.2		
13- 17		0.9	69.0	30.1	6.1	10.0		0.34		5.2		
17- 22		0.8	68.3	30.9	5.7	14.6		0.24		6.0		
22- 26		1.0	68.1	30.9	5.5	18.5		0.22		6.0		
26- 32		0.9	71.6	27.5	5.6	32.8		0.14		5.2		
32- 37		0.9	73.0	26.1	5.8	27.3		0.12		4.0		
37- 43		0.8	74.1	25.1	5.9	22.8				3.6		
43- 49		0.6	75.8	23.6	6.1	20.3				3.2		
49- 55		0.5	76.2	23.3	6.1	21.0				3.2		
55- 61		0.5	77.0	22.5	5.9	20.7						
61- 67		0.6	79.3	20.1	6.0	22.5						
67- 73		0.7	79.9	19.4	6.0	24.3						
73- 78		5.0	75.9	19.1	5.9	26.5						
78- 83		27.5	55.1	17.4	5.9	24.6						
83- 86		36.8	47.3	15.9	6.1	25.0						
86- 92		73.2	17.9	8.9	6.1	17.8						
92- 97		39.2	46.6	14.2	6.0	25.8						
97-103		20.7	67.4	11.9	5.9	23.5						
103-109		44.1	42.5	13.4	5.9							
109-114		42.5	46.0	11.5	6.5							
114-119		33.2	51.5	15.3	6.2							
119-124		64.8	25.8	9.4	7.0							
124-129		83.8	9.1	7.1	7.2			0.16				
129-133		20.2	64.8	15.0	7.3			0.34				
133-138		5.7	77.1	17.2	7.6			1.12	9.32			
138-140		21.5	48.9	29.6	7.6			0.19				
140-144		2.1	82.6	15.3	7.7			1.51	12.57			
144-147		0.6	90.3	9.1	7.7			2.20	18.31			
147-154		0.2	87.4	12.4	7.4			2.83	23.57			

PROFILE NUMBER: 16-M29 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC < 2
154-160		1.6	80.6	17.8	7.4			1.00	8.90			
160-166		0.5	78.9	20.6	7.3			0.27	0.13			
166-169		0.5	69.3	30.2	7.1	10.8		0.31	0.18			
169-172		0.5	67.1	32.4	7.1	10.8		0.24				
172-176		0.9	67.1	32.0	7.2	10.0		0.13				
176-181		0.9	64.8	34.3	7.2	12.1		0.05				
181-184		2.3	61.4	36.3	7.1	6.8						
184-188		1.9	56.2	41.9	7.0	6.5						
188-192		0.3	56.1	43.6	7.0	9.0						
192-196		0.7	61.7	37.6	7.1	6.4						
196-201		1.3	60.7	38.0	7.0	2.4						
201-205		1.3	53.3	45.4	7.0	1.0						
205-209		2.3	57.2	40.5	7.1	1.0						
209-214		3.8	54.4	41.8	7.2	1.5						
214-219		3.1	55.6	41.3	7.6	2.8						
219-225		3.3	54.2	42.5	7.6	2.8						

PROFILE NUMBER: 16-M29

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
0- 6	0.0	0.0	0.0	0.0	1.1	26.3	17.6	15.5	7.2	4.8	20.3	1.1	71.4	27.5
6- 9	0.0	0.0	0.0	0.0	0.8	21.5	23.9	14.1	6.9	4.2	19.9	0.8	70.6	28.6
9- 13	0.0	0.0	0.0	0.0	0.9	17.9	25.8	14.4	7.0	4.2	19.1	0.9	69.3	29.8
13- 17	0.0	0.0	0.0	0.0	0.9	18.7	25.1	14.6	6.6	4.0	19.5	0.9	69.0	30.1
17- 22	0.0	0.0	0.0	0.0	0.8	18.0	24.4	15.2	6.8	3.9	19.2	0.8	68.3	30.9
22- 26	0.0	0.0	0.0	0.0	1.0	20.7	26.3	12.2	5.7	3.2	21.2	1.0	68.1	30.9
26- 32	0.0	0.0	0.0	0.0	0.9	21.2	27.8	13.5	5.6	3.5	21.0	0.9	71.6	27.5
32- 37	0.0	0.0	0.0	0.0	0.9	21.2	29.2	14.0	5.6	3.0	21.2	0.9	73.0	26.1
37- 43	0.0	0.0	0.0	0.0	0.8	22.6	29.1	14.5	5.1	2.8	21.7	0.8	74.1	25.1
43- 49	0.0	0.0	0.0	0.0	0.6	23.1	29.9	14.0	5.7	3.1	21.5	0.6	75.8	23.6
49- 55	0.0	0.0	0.0	0.0	0.5	21.9	31.0	14.6	5.7	3.0	21.1	0.5	76.2	23.3
55- 61	0.0	0.0	0.0	0.0	0.5	20.7	32.2	15.0	6.1	3.0	20.7	0.5	77.0	22.5
61- 67	0.0	0.0	0.0	0.0	0.6	22.7	33.7	14.6	5.8	2.5	21.7	0.6	79.3	20.1
67- 73	0.0	0.0	0.0	0.0	0.7	23.0	34.1	14.8	5.1	2.9	21.8	0.7	79.9	19.4
73- 78	0.0	0.3	1.7	1.6	1.4	23.0	32.0	13.3	5.0	2.6	25.2	5.0	75.9	19.1
78- 83	0.0	1.2	3.3	12.4	10.6	25.9	18.0	7.0	2.5	1.7	48.4	27.5	55.1	17.4
83- 86	0.1	2.0	13.0	13.8	7.9	20.6	16.0	6.5	2.5	1.7	65.1	36.8	47.3	15.9
86- 92	0.0	3.2	36.6	24.8	8.6	9.3	4.8	1.9	1.1	0.8	165.4	73.2	17.9	8.9
92- 97	0.0	1.9	15.4	13.4	8.5	24.5	14.3	5.2	1.3	1.3	73.3	39.2	46.6	14.2
97-103	0.0	0.9	5.3	6.2	8.3	32.3	20.7	6.3	2.6	5.5	39.2	20.7	67.4	11.9
103-109	0.0	1.2	11.4	16.5	15.0	24.7	11.4	3.9	1.8	0.7	75.5	44.1	42.5	13.4
109-114	0.1	3.9	18.5	11.9	8.1	23.5	14.8	4.2	2.1	1.4	80.1	42.5	46.0	11.5
114-119	0.1	1.5	14.0	11.5	6.1	24.1	15.9	7.0	3.1	1.4	61.4	33.2	51.5	15.3
119-124	0.1	5.8	32.0	19.6	7.3	25.8	0.0	0.0	0.0	0.0	166.8	64.8	25.8	9.4
124-129	0.1	5.7	46.8	23.8	7.4	9.1	0.0	0.0	0.0	0.0	239.4	83.8	9.1	7.1
129-133	0.0	3.2	6.6	5.7	4.7	26.4	24.4	8.5	3.6	1.9	42.9	20.2	64.8	15.0
133-138	0.0	0.3	1.6	1.6	2.2	28.7	28.9	11.7	4.9	2.9	26.8	5.7	77.1	17.2
138-140	0.1	1.6	8.1	7.8	3.9	21.6	10.7	7.3	5.8	3.5	44.3	21.5	48.9	29.6
140-144	0.0	0.0	0.0	0.0	2.1	18.7	37.3	16.2	6.8	3.6	20.4	2.1	82.6	15.3
144-147	0.0	0.0	0.0	0.0	0.6	15.8	40.2	22.3	8.5	3.5	18.4	0.6	90.3	9.1

PROFILE NUMBER: 16-M29 (CONTINUED)

% PARTICLE-SIZE IN MICRONS

DEPTH (INCHES)	2000 1000	1000 500	500 250	250 125	125 62	62 31	31 16	16 8	8 4	4 2	GM	2000 62	62 2	< 2
147-154	0.0	0.0	0.0	0.0	0.2	12.3	37.7	24.1	9.1	4.2	17.0	0.2	87.4	12.4
154-160	0.0	0.0	0.0	0.0	1.6	11.8	30.5	20.8	11.0	6.5	15.9	1.6	80.6	17.8
160-166	0.0	0.0	0.0	0.0	0.5	9.0	26.8	24.1	11.5	7.5	14.1	0.5	78.9	20.6
166-169	0.0	0.0	0.0	0.0	0.5	9.4	24.8	19.0	10.6	5.5	15.0	0.5	69.3	30.2
169-172	0.0	0.0	0.0	0.0	0.5	11.6	21.9	19.0	10.5	4.1	15.8	0.5	67.1	32.4
172-176	0.0	0.0	0.0	0.0	0.9	9.3	25.4	18.1	10.1	4.2	15.8	0.9	67.1	32.0
176-181	0.0	0.0	0.0	0.0	0.9	9.9	20.6	20.2	9.3	4.8	15.3	0.9	64.8	34.3
181-184	0.0	0.0	0.0	0.0	2.3	9.4	21.9	16.3	8.9	4.9	16.2	2.3	61.4	36.3
184-188	0.0	0.0	0.0	0.0	1.9	7.9	19.4	16.8	8.0	4.1	15.9	1.9	56.2	41.9
188-192	0.0	0.0	0.0	0.0	0.3	7.8	17.8	16.9	9.1	4.5	14.5	0.3	56.1	43.6
192-196	0.0	0.0	0.0	0.0	0.7	8.4	20.2	18.6	9.5	5.0	14.8	0.7	61.7	37.6
196-201	0.0	0.0	0.0	0.0	1.3	6.4	23.2	17.4	9.3	4.4	15.1	1.3	60.7	38.0
201-205	0.0	0.0	0.0	0.0	1.3	9.3	16.3	15.0	8.1	4.6	15.6	1.3	53.3	45.4
205-209	0.0	0.0	0.0	0.0	2.3	8.9	18.1	16.8	8.9	4.5	15.8	2.3	57.2	40.5
209-214	0.0	0.0	0.0	0.0	3.8	9.4	16.5	15.4	8.6	4.5	16.8	3.8	54.4	41.8
214-219	0.0	0.0	0.0	0.0	3.1	8.7	17.2	16.1	8.7	4.9	16.0	3.1	55.6	41.3
219-225	0.0	0.0	0.0	0.0	3.3	9.2	16.4	15.6	8.5	4.5	16.4	3.3	54.2	42.5

PROFILE NUMBER: 16-M3C

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		1.1	72.4	26.5	7.0	61.0		2.14				
7- 11		1.3	70.0	28.7	6.9	49.0		1.97				
11- 15		1.3	68.6	30.1	6.2	7.0		1.50				
15- 19		1.1	67.5	31.4	5.9	5.5		1.51				
19- 26		1.1	65.2	33.7	6.0	7.5		0.83				
26- 31		1.1	67.2	31.7	6.1	22.5		0.28				
31- 34		1.0	68.2	30.8	6.4	20.0		0.22				
34- 40		0.9	69.0	30.1	6.4	15.5		0.22				
40- 46		1.0	70.8	28.2	6.5	12.5		0.18				
46- 52		1.3	71.0	27.7	6.7	17.0		0.15				
52- 58		0.7	74.3	25.0	6.7	22.5						
58- 63		0.8	74.2	25.0	6.8	19.0						
63- 66		2.2	75.2	22.6	7.0	6.5						
66- 71		1.5	73.0	25.5	7.0	9.0						
71- 75		0.8	75.8	23.4	7.0	9.3						
75- 78		0.7	76.4	22.9	7.2	11.5						
81- 87		0.3	77.3	22.4	7.4	7.0						
87- 93		0.7	81.0	18.3	7.6	5.0						
93- 99		0.6	80.8	18.6	7.5	8.0						
99-105		0.8	80.0	19.2	7.3	6.8						
105-111		0.6	79.8	19.6	7.8	4.8						
111-117		0.5	81.5	18.0	7.8	5.0						
117-124		0.7	79.9	19.4	7.8	4.5						

PROFILE NUMBER: 16-M34

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 7		1.5	71.8	26.7	7.1	78.6		2.71		3.6	22.4	0.84
7- 11		0.9	69.6	29.5	6.9	38.0		1.49		4.4	20.7	0.70
11- 15		0.9	68.1	31.0	6.8	12.5		1.14		4.8	21.9	0.71
15- 19		0.6	67.4	32.0	6.7	8.6		0.93		5.2	22.8	0.71
19- 22		0.6	67.2	32.2	6.4	7.7		0.73		4.8	22.0	0.68
22- 26		0.6	67.0	32.4	6.3	18.5		0.55		4.8	22.4	0.69
26- 31		0.6	67.7	31.7	5.9	26.2		0.50		5.6	24.4	0.77
31- 36		1.0	68.1	30.9	5.9	35.0		0.29		5.2	24.5	0.79
36- 41		1.4	71.8	26.8	6.1	33.0		0.32		4.0	23.6	0.88
41- 46		1.3	72.0	26.7	6.1	31.0		0.31		3.6	23.1	0.87
46- 51		2.9	73.0	24.1	6.2	29.7		0.42		3.2	23.6	0.98
51- 57		1.9	73.8	24.3	6.2	27.7		0.37			23.6	0.97
57- 63		4.5	72.8	22.7	6.1	20.8						
63- 69		3.1	73.5	23.4	6.2	22.5						
69- 75		1.2	75.8	23.0	6.2	23.7						
75- 81		1.5	77.0	21.5	6.5	23.7						
81- 87		1.2	79.3	19.5	6.7	20.8						
87- 92		1.2	84.5	14.3	7.4	14.2						
92- 97		0.9	85.1	14.0	7.6	11.5						
97-103		2.0	86.6	11.4	7.6	8.5						
103-108		6.9	79.8	13.3	7.9							
108-114		38.9	39.0	22.1	7.8							
114-120		41.9	34.3	23.8	8.0							
120-126		41.7	35.2	23.1	8.0							
126-132		41.4	34.9	23.7	8.0							

PROFILE NUMBER: 16-M41

DEPTH (INCH.)	>2 MM	% PARTICLE-SIZE 2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 8		1.8	73.2	25.0	7.0	75.0		1.78		4.4	17.0	0.68
8- 13		1.3	71.5	27.2	6.4	30.8		1.72		8.4	17.6	0.65
13- 17		1.2	70.4	28.4	6.0	6.4		1.20		8.4	14.9	0.52
17- 22		1.2	69.9	28.9	5.9	4.2		0.96		8.4	16.8	0.58
22- 27		1.1	69.4	29.5	5.8	3.0		0.65		8.0	16.9	0.57
27- 31		1.2	69.7	29.1	5.9	7.6		0.49		7.2	19.1	0.66
31- 36		1.7	70.0	28.3	5.5	16.8		0.30		6.4	19.4	0.69
36- 42		2.6	71.1	26.3	5.6	35.0		0.24		5.2	19.1	0.73
42- 47		10.5	62.7	26.8	5.6	44.0				6.4	19.3	0.72
47- 51		14.0	59.3	26.7	5.7	45.5				5.6	17.5	0.66
51- 57		62.5	22.6	14.9	5.9	25.5				2.8		
57- 63	3.6	78.0	10.2	11.8	6.0	22.0				2.8		
63- 69	2.5	60.1	27.3	12.6	6.0	19.8				2.0		
69- 75	2.0	59.2	23.0	17.8	6.2	18.8				1.6		
75- 81	2.9	44.6	34.9	20.5	6.1	19.3				2.4		
81- 87	4.4	44.0	36.0	20.0	6.5	19.8				2.0		
87- 92	0.8	43.6	33.4	23.0	7.3	19.5			2.32	0.8		

PROFILE NUMBER: 82-M 1

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC / < 2
0- 3		1.0	73.6	25.4	5.7	33.0		2.26				
3- 7		0.7	73.1	26.2	5.6	20.4		1.80				
7- 12		0.9	69.3	29.8	5.5	9.4		1.33				
12- 16		0.6	67.6	31.8	5.4	6.2		0.90				
16- 19		0.6	66.3	33.1	5.4	7.1		0.59				
19- 24		0.7	66.1	33.2	5.4	10.1		0.47				
24- 28		0.7	67.4	31.9	5.4	15.5		0.43				
28- 33		0.6	69.6	29.8	5.8	25.5		0.24				
33- 37		0.8	68.4	30.8	5.7	33.6		0.21				
37- 42		0.9	70.2	28.9	5.7	28.9		0.15				
42- 48		0.6	71.3	28.1	5.8	24.2						
48- 54		0.6	73.3	26.1	5.9	22.7						
54- 60		0.6	74.1	25.3	5.9	19.0						
60- 66		0.5	75.7	23.8	6.0	20.4						
66- 72		0.6	77.4	22.0	6.3	22.9						
72- 78		1.0	78.4	20.6	6.5	20.4						
78- 84		1.0	85.2	13.8	7.2	14.5						
84- 90		1.0	86.6	12.4	7.4	13.3						
90- 96		0.9	86.0	13.1	7.6	4.2						
96-102		0.9	86.5	12.6	7.7	4.5						
102-108		0.8	88.0	11.2	7.8	4.7						
108-114		1.8	83.4	14.8	7.8	8.3						
114-116		3.6	81.4	15.0	7.6	3.1						
116-120		18.3	65.4	16.3	7.6	5.2						
120-126	0.3	43.3	33.5	23.2	7.3	11.3						
126-132	4.7	44.2	32.5	23.3	7.3	6.0						
132-138	2.8	43.7	32.1	24.2	7.4	5.5						
138-144	2.0	44.2	33.5	22.3	7.4	5.2						
144-150	1.7	42.0	36.4	21.6	7.3	3.1						
150-156	0.5	42.7	35.2	22.1	7.5	6.4						
156-162	1.8	42.2	35.8	22.0	7.4	7.7						

PROFILE NUMBER: 82-M 1 (CONTINUED)

DEPTH (INCH.)	% PARTICLE-SIZE >2 MM	2000 -62	62 -2	<2	PH	AP1 PPM	AP2 PPM	% OC	CO3 EQ	EA MEQ	CEC MEQ	CEC < 2
162-168	1.0	43.7	34.6	21.7	7.4	6.8						
168-174	3.9	43.4	34.3	22.3	7.4	6.8						
174-180	0.1	43.4	34.9	21.7	7.2	10.4						
180-186	0.3	43.0	35.2	21.8	7.3	7.3						
186-192	0.3	43.0	35.5	21.5	7.3							
192-198		42.9	34.7	22.4	0.0							
198-204	0.8	41.9	35.9	22.2	0.0							
204-210		44.2	34.4	21.4	0.0							
210-214		43.0	34.7	22.3	0.0							